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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CIII.—No. 2666.] *LONDON: FRIDAY, FEBRUARY 2, 1917.* [*Registered at the General Post Office as a Newspaper.*] PRICE 6d. BY INLAND POST, 6d.

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See Advertisement, page 29.
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Specification and Workmanship equal to Main Line Locomotives.
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SYSTEMS { PRESSURE. AIR. STEAM.
FOR BOILERS OF ALL TYPES.
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NAVAL OUTFITS A SPECIALTY.

Locomotives Tank Engines
designed and constructed by
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See their Illus. Advertisement page 97, last week.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
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See page 86, Jan. 26. 5784

Improved High Pressure
RENEWABLE DISC GLOBE VALVE.
See our Advertisement in last week's issue, page 90.
BRITISH STEAM SPECIALITIES, LTD.,
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MACHINE BELTING
FOR
Driving
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BY
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Offices: 2, Arlington Street, St. James's, S.W. Tel: Gerrard, 3466.
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Tubes and Fittings.
—
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 58. 5707

Several Generating Sets for
SALE from 100 KW. to 800 KW., D.C. and A.C., usual voltages.
300 KW. GENERATING SET, enclosed High Speed Engine, two phase, 50 periods, 2,300 volts.
52 HP. MOTOR, three phase, 900 r.p.m.
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Fine Red Moulding Sand,
FOR
IRON, BRASS, ALUMINIUM.
APPLY,
Mansfield Sand Co., Ltd.,
MANSFIELD, NOTTS. 5178

The Norman Thompson Flight Co., Ltd. (Estd. 1909.)
CONTRACTORS TO THE ADMIRALTY.
Seven years' experience
in Design and Construction of Aircraft.
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ALL BRITISH BUILT. 5399
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Vertical DRILLS, to admit 16 in., 20 in., and 30 in. diameter. Bolt Screwing MACHINES. 10½ in. centre Special Shafting LATHE. Second-hand PLANERS, 36 ft. by 6 ft. by 6 ft.
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Dish End Boilers, 30 ft. by 9 ft. 3 in. 150 w.p.
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OF ALL DESCRIPTIONS.
FLOATING CRANES, COAL BUNKERING VESSELS. 5234
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See half-page Advertisement, last and next week.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
STEAM AND GAS KETTLES. } Row's Patents
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SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
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LEVENFORD WORKS, Dumbarton. 4304
See Full Page Advt. page 46, Jan. 12.

Forgings.
Walter Somers & Co., Ltd.,
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Punch and Shear Machine
SPECIALISTS. 4794
Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860.
SCOTT BROS., WEST MOUNT, HALIFAX.

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FURNACES 4640
MONOMETER MANUFACTURING CO., LTD.,
ASTON, BIRMINGHAM.
See Advertisement page 54, Jan. 19.

Head, Wrightson & Co.,
LIMITED,
See Advertisement page 26, Jan. 19. 2468

Gas Engines, Suction Plants,
Inspections, Tests and Reports. Expert advice.—B. J. DAVIS, M.I. Mech. E., Great Eastern Road, Stratford. Telephones: East 1250; Stratford 569. Tel.: Rapidising, London. 1794

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1869.
Address, BURNETT AVENUE, HULL.
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Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals.
—
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
5466
See half-page Advertisement page 78, Jan. 26.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir W. FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5169

TENDERS.

TO MAKERS AND USERS OF LOCOMOTIVES.

The MINISTRY OF MUNITIONS are prepared to receive

Offers for New or Good Second-hand SHUNTING LOCOMOTIVES of various sizes.

The following information must accompany each offer, which must be addressed to Mr. HUBERT BAINES, Deputy Chief Engineer, H.M. Office of Works, Ring Charles Street, Whitehall, London, S.W.: Type; size and weight; maker's name; when built; when and by whom last overhauled; condition; price.

H.M. Office of Works, &c.,
17th January, 1917. F 972

TO MAKERS AND USERS OF STEAM LOCOMOTIVE CRANES.

The MINISTRY OF MUNITIONS are prepared to receive

Offers of Good Second-hand STEAM TRAVELLING CRANES of various sizes.

The following information must accompany each offer, which should be addressed to Mr. HUBERT BAINES, Deputy Chief Engineer, H.M. Office of Works, Storey's Gate, Westminster, London, S.W.:—Type; lifting power, whether 2, 3 or 5 tons; radius of maximum lift; maker's name; condition; where seen; price. All for standard gauge only.

H.M. Office of Works, &c.,
17th January, 1917. F 973

PRELIMINARY ANNOUNCEMENT.
THE PUBLIC TRUSTEE will shortly

Offer for Sale by Private TENDER, 119,660 SHARES of £5 each, fully paid, in SIEMMENS BROTHERS and COMPANY (Limited),

Full particulars and forms of tender are now in course of preparation, and will be issued at an early date.

Intending tenderers who are desirous of inspecting the works should apply to the Public Trustee in writing for permission to do so, and they must be prepared to furnish full information to the Public Trustee on being required to do so. G 87

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of the Whole or any part of 3,579 "A" Shares of £10 each, fully paid, and 1,200 "B" Shares of £10 each, fully paid, in the TUDOR ACCUMULATOR COMPANY, LIMITED, vested in him as Custodian by an Order of the Board of Trade, dated the 2nd October, 1916.

The issued capital of the Company consists of 3,800 "A" Shares of £10 each, fully paid, and 1,200 "B" Shares of £10 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

A report upon the result of the past operations, and the present position of the Company, has been made to the Public Trustee by Messrs. KNOX, CROPPER & COMPANY, Chartered Accountants, of Spencer House, South Place, E.C., and this report, together with copies of the Company's Accounts, can be inspected either at the Offices of the Public Trustee, Kingsway, W.C., or at those of Messrs. KNOX, CROPPER & COMPANY.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Monday, the 26th February, 1917 (instead of 5th February, as previously advertised), at Twelve Noon, marked on the envelope, "Tender, Tudor Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith. F 969

Forms of Tender can be obtained from the PUBLIC TRUSTEE, or from Messrs. KNOX, CROPPER AND COMPANY, Spencer House, South Place, E.C.

ORENSTEIN & KOPPEL—ARTHUR KOPPEL (EGYPT), LTD. (IN LIQUIDATION).

SALE OF DESIGNS FOR LIGHT RAILWAY MATERIAL.

Notice is Hereby Given that Mr. E. H. RUSSELL, Receiver of ORENSTEIN & KOPPEL—ARTHUR KOPPEL (EGYPT), LTD. (In Liquidation), will SELL, by order of the Military Authorities, DESIGNS FOR LIGHT RAILWAY CONSTRUCTION belonging to this concern, consisting principally of Wagons, Railway Points, Turning Tables, Locomotives, &c., &c., according to a list which may be inspected by the Public.

These designs represent various types of wagons, &c., employed in Egypt and the Colonies, and are the result of years of study and experience. This firm had practically the monopoly of this kind of business in Egypt prior to the war.

Offers for these designs, together with a deposit of 10 per cent. of the sum offered, will be received at the offices of the Receiver in Cairo and in London (at the addresses given below) up to the close of business hours on Wednesday, 21st February, 1917.

The sale will be made for cash without any kind of guarantee whatsoever by the seller.

The person to whom the designs are sold must pay the balance of the price on the receipt of these designs, which will be delivered in Egypt within two months of the acceptance of the offer.

The Receiver may accept or refuse any offer without giving any reason therefor. Those tendering will be bound by their offers for two months after 21st February, 1917.

Further information may be obtained from the Offices of the RECEIVER in Cairo and in London.

Address of the Receiver's Cairo Office:—"Gresham House," Sharia Sulfman Pasha, Cairo.

Address of the Receiver's London Office:—"Palmerston House," Old Broad Street, London, E.C. G 70

CORPORATION OF HARROGATE.
BY SPECIAL LICENSE FROM THE MINISTRY OF MUNITIONS.
The Electricity Committee invite

Tenders for the Supply and ERECTION in the Electricity Works of a BY-PRODUCT STEAM BOILER, OVERHEAD COAL BUNKER, COAL CONVEYOR and STRUCTURAL STEEL WORK.

Specifications may be obtained from the undersigned on deposit of the sum of Two Guineas, which deposit will be returned on receipt of a *bona fide* Tender, to which must be attached the Specifications. Tenders, addressed as below must be delivered, sealed and marked, "Tender for By-Product Steam Boiler Plant," not later than March 5th, 1917.

The Corporation does not bind itself to accept the lowest or any Tender.

GEO. WILKINSON, M.I.E.E., M.I.M.E.,
Borough Electrical Engineer.
Corporation Electricity Department,
83, Swan Road, Harrogate,
January, 1917. G 66

GREAT NORTHERN RAILWAY COMPANY (IRELAND).

The Great Northern Railway Company (Ireland) are prepared to receive

Tenders for :—

150 PAIRS OF WAGON WHEELS AND AXLES.

Copies of the Specification, Drawings, and Form of Tender may be obtained on application to the Secretary, at Amiens Street Terminus, Dublin, on payment of a fee of 10s., which will be refunded on receipt of a bona fide Tender and the return of the Drawings.

Tenders, under cover, marked "Tender for Wagon Wheels and Axles," should be delivered to the undersigned not later than Ten a.m. on Monday, the 26th February, 1917.

The Directors do not bind themselves to accept the lowest or any Tender.

T. MORRISON,
Secretary.
Secretary's Office, Amiens Street Terminus,
Dublin, 31st January, 1917. G 97

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—
INDIA-RUBBER SHEETS, &c.
CANVASES,
WHITE LEAD,
BELLOWS,
FENCING WIRE STRAND,
JIM CROWS.

Specifications and Forms of Tender may be obtained at this Office on payment of the Fee for the Specification, which payment will not be returned.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for India-Rubber Sheets, &c.," or as the case may be, not later than Eleven o'clock, a.m., on Thursday, the 8th February, 1917.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Company's Offices, Secretary.
48, Copthall Avenue, London, E.C.
31st January, 1917. G 100

COUNTY BOROUGH OF BELFAST.
WORKS DEPARTMENT.
TENDERS FOR STORES, WORK, AND UNIFORM CLOTHING.

The WORKS COMMITTEE are prepared to receive

Tenders for the supply of the following STORES, WORK, and UNIFORM CLOTHING, for the year commencing 1st April, 1917:—

Earthenware Sewer Pipes.	Shovels, Spades, Grapes & Buckets.
Timber.	Scavenging Brushes.
Slates.	Glazed Bricks.
Hardwood.	Artificial Flags.
Iron Castings.	Lime.
Plumbers' Work.	Pitch, Felt, Tar, &c.
Nails, &c.	Sea Sand, Sea Gravel, & Lough Neagh Sand.
Iron and Steel.	Cement.
Paints, Oils, &c.	Uniform Clothing & Hats.
Glazing.	
Mill Furnishings.	

Forms of Tender and particulars may be obtained from Mr. Hector F. Gullan, M.Inst.C.E., Superintent of Works, City Hall.

Sealed Tenders, on official forms only, endorsed "Tender for....., Works Department," to be lodged in my Office before 12 o'clock noon on 13th February.

The lowest or any Tender will not necessarily be accepted.

The whole, or any part, of a Tender may be accepted.

An official receipt must be obtained for every Tender delivered by hand. Tenders sent by post must be registered.

R. MEYER,
G 92 Town Clerk.

APPOINTMENTS OPEN.

IRON FOUNDRY MANAGER.

David Brown & Sons (Hfd) Ltd., Gear Specialists, Park Works, Lockwood, Huddersfield, REQUIRE the SERVICES of a thoroughly competent and progressive Iron Foundry MANAGER accustomed to machine moulding and to economical production. Output approximately 20 tons weekly, small repetition work to castings up to 10 tons each.

Apply in the first instance in writing, giving full particulars of qualifications and experience, stating age and salary expected. Applicants employed on War Work will only be considered with the sanction of their present employers. G 63

Wanted, Mill Manager, for cogging, roughing and finishing mill, experienced in rails, sheet bars, and billets; one experienced in shell bar rolling and gas heating preferable. State age, reference, and salary required.—Address, F 934, Offices of ENGINEERING.

Wanted, Manager, Take charge of Shrapnel Shell Shop, output about 3,000 a week. No person engaged on Government work will be employed.—Address, stating qualifications, age, and salary required, G 83, Offices of ENGINEERING.

The Management of a Large Engineering Works, usually manufacturing Steam Turbines, Steam Engines, &c., at present engaged on high-class Gun Work, REQUIRE the SERVICES of a first-class Tool Room FOREMAN. Must have held similar position, and be capable of re-organizing existing Tool Room System.

He must be accustomed to high class and modern design of tools, jigs, and gauges. The position offers good prospects, and suitable salary would be paid to the right man. Applicants should give full details of training, experience and salary required, and when at liberty. No one employed on Government work will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, quoting No. A 2862. G 43

Required, Immediately, a LIVE MAN for Works Planing Department of a moderately large Aeroplane Factory. Applicants must have had experience of systems obtaining in large engineering works. Should be capable of determining operations, fixing of piece-work, and bonus rates, &c. Only really live men with considerable experience need apply. No one already employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 990.

Wanted, by a Government Controlled Firm of Engineers and Optical Instrument Makers in Leicester (at present on Munitions work), an EXPERIENCED MAN for research in applied physics and mechanics, to deal with problems in connection with design and manufacturing processes. No one already on Government work will be engaged without the consent of previous employers.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal and G 21.

Engineer, with Business experience, to Assist Managing Director in London offices. Experience with Iron and Steel-works plant and heavy machinery an advantage. Intelligence and energy essential. Ample scope for progress to the right man.

Also several good DRAUGHTSMEN REQUIRED. No person at present employed on Government work will be engaged.—Apply, with full particulars, to nearest EMPLOYMENT EXCHANGE, quoting this Journal and G 45.

Works Manager Wanted for WORKS in London. Must be experienced in repetition Standard work, capable of handling about 500 men, and also able to deal expeditiously with special work. Age desirable 35 to 40.—Write, stating age, experience, etc., to Box 4564, care of JUDD'S, 97, Gresham Street, London. G 100

Wanted, Works Manager, for important Aviation Company in London, on Government Contracts; must have held similar position in large aviation or engineering works.—Applications, which will be treated in strict confidence, should be addressed, G 79, Offices of ENGINEERING.

Wanted, First-class Blast FURNACE ENGINEER (British). One conversant with modern American and Continental practice preferred.—Address, stating age, experience, and salary expected to G 53, Offices of ENGINEERING.

The Midland Employers' FEDERATION REQUIRE at their Birmingham offices the Services of an ASSISTANT to Secretary. Salary not less than £500 a year.—Apply, by letter only, stating qualifications, &c., to CHAIRMAN of the M. E. F., Exchange Buildings, Birmingham. (No application considered from persons eligible for military duties.) G 85

Assistant to Chief Engineer WANTED, in London Factory, must have good practical experience and technical training, and be accustomed to the control of men. No one already engaged on Government work will be considered.—Address, stating age, experience and salary required, G 53, Offices of ENGINEERING.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will, in 1917,

Appoint a Few Natives of India as ASSISTANT ENGINEERS in the Indian Public Works and State Railway Departments.

Candidates must be British subjects, and, save as provided in Appendix III to the Regulations, must be not less than 21 and not more than 24 years of age on the 1st July, 1917. They must have either obtained one of certain recognised University degrees or other distinctions in Engineering, or have passed the Associate Membership Examination of the Institution of Civil Engineers.

Applications must reach the India Office by 31st March, 1917. Printed Forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, London, S.W.

India Office, London,
1st December, 1916. F 621

GOSPORT AND ALVERSTOKE URBAN DISTRICT COUNCIL.

The above Council invite

Applications for the Appoint- MENT of ENGINEERING FITTER, at their Sewage Air Compressing Station.

Applicants must be ineligible for Military service. Wages, £2 7s. 6d. per week.

List of duties and form of application may be obtained on application to Mr. H. FROST, Surveyor to the Council, Gosport.

Applications, accompanied by copies of two testimonials of recent date, must be sent to the undersigned not later than Twelve o'clock noon, on Thursday, the 8th proximo, endorsed "Engineering Fitter."

By Order,
H. H. MANGNALL,
Council Offices, Gosport. Clerk.
18th January, 1917. F 993

Junior Inspecting Engineer, age 21 to 25, WANTED by large firm of general engineers in the Midlands. To inspect small iron and steel forgings, malleable and grey castings, munitions of war. Must have previous shop experience. Inexperts for Army preferred. No person already on Government work will be engaged. —Apply, giving full particulars, experience, age, and salary required to your nearest EMPLOYMENT EXCHANGE, quoting No. A2963. G 62

BRISTOL EDUCATION COMMITTEE.

Wanted, Headmaster for the Bristol Junior Technical School (Engineering), to be opened immediately after Easter.

Salary, £260 per annum.

Applications, stating age, full qualifications, and experience, together with copies of three recent testimonials, to be sent to the undersigned before noon on Monday, 12th February.

WM. AVERY ADAMS,
Guildhall, Bristol, Secretary for Education.
25th January, 1917. G 61

Required, One Day and One Night WORKS SUPERINTENDENT for a moderately large Aeroplane Factory in the Midlands. Applicants should possess a good all round knowledge of workshop practice and system, and capable of controlling men. Men are preferred who have had experience in large engineering works manufacturing standard articles. No one already employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 989.

Designer, with Good Mech- anical Engineering experience, REQUIRED by Admiralty establishment for the duration of the war. No others need apply.—Reply (by letter), stating age, experience, and present salary to BOX No. 919, care of Messrs. R. F. WHITE & SON, Genl. Advng. Agents, 35, Fleet Street, London, E.C. F 866

Wanted, First-class Leading DRAUGHTSMAN, ineligible for Military service, thoroughly conversant with aerial ropeways. State experience and salary required. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal, and G 54.

Draughtsmen.—Wanted, for large munition works in South Wales, TWO good DRAUGHTSMEN. Men with knowledge of chemical or general engineering and having experience in the supervision of repairs preferred. No person on Government work will be engaged.—Apply, stating full particulars of experience, and wages required, to nearest EMPLOYMENT EXCHANGE, quoting No. A 2694. G 48

Draughtsman, Mechanical, Wanted, to take leading position in Drawing Office in new Company in Midlands engaged upon urgent War Work. Excellent prospects for a young energetic man. One with some experience in jig and tool design and automobile construction preferred. No man on Government work can be engaged without consent of present employers. Applications in the first instance should be made to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this paper & No. A 2778. F 992

Draughtsman Required, with full knowledge of Diesel engine design. Must have successfully been responsible for designs from start to finish, and be conversant with all details, both theoretical and practical. No one already employed on Government work will be engaged.—Apply, in confidence, in first instance, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and F 985.

Required, by Government Controlled Works, JIG AND TOOL DRAUGHTSMAN, used to heavy commercial Vehicles and Petrol Engines. No one engaged on Government work need apply. State age, references, etc.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this paper, and No. A 2829. G 36

Draughtsman Wanted, in Westminster office, for Government work of high importance. Accustomed to design of light accurate electrical and mechanical instruments. Some workshop experience essential. Permanent position with good remuneration for capable man.—State full particulars of age, training, experience, and salary required (applications from men at present engaged on war work cannot be considered), to your nearest EMPLOYMENT EXCHANGE, quoting No. A 2810. F 991

Draughtsman Required, preferably with experience in the design of hardening and metal melting furnaces.

No one already employed on Government work will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 82.

Draughtsmen. — Several Mechanical DRAUGHTSMEN for turbine design and detail WANTED by a controlled firm in the Midlands. Liberal salaries and bonuses to men who can make good. No man on Government work need apply.—Apply, stating salary, and when able to commence, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2799. F 933

Wanted, Draughtsman for Controlled Establishment. One with knowledge of grinding and seed crushing plant preferred but not essential. No one already engaged on Government work need apply.—Apply, stating full particulars and salary required, to your nearest LABOUR EXCHANGE, mentioning this Journal and F 985.

Experienced Draughtsmen REQUIRED, for general engineering work, Birmingham district, to assist in development of processes and efficiency work. Permanency to suitable men. State full particulars of experience, age, salary required, and whether free, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 2845. No person already on Government work will be engaged. G 60

Wanted, a Machine Shop FOREMAN or SUPERINTENDENT for night shift in a Government controlled establishment in the North of England engaged on the manufacture of motor transport vehicles.

Applicants, who must have had similar previous experience and capable of controlling both male and female labour, should apply to their nearest EMPLOYMENT EXCHANGE, quoting Ref. No. A2835, giving full particulars of experience, age and wages required.

No person already on Government work will be engaged. F 988

LITERATURE.

Practical Shipbuilding. By A. CAMPBELL HOLMS, Surveyor to *Lloyd's Register of Shipping*. 3rd Edition. 2 vols. Vol. I, *Text*; Vol. II, *Diagrams and Illustrations*. London, New York and Bombay: Longmans, Green and Co. [Price 52*s*. 6*d*. net.]

THE printing of new and revised editions of well-known text-books on any subject may be taken as indicative of a spirit of life and progression in that subject, and it is therefore particularly gratifying to find that new editions of several of the leading text-books on both the theoretical and practical sides of naval architecture have recently been issued. To the latter class falls to be added "Practical Shipbuilding," by Mr. A. Campbell Holms, a work which has already proved of very great value to many of those engaged in the work of ship design, construction and maintenance.

Considering the vast importance of the subject it is surprising that the number of modern text-books, particularly those dealing with the practical side of shipbuilding, is so small. To some extent this may be due to the vast field which must be covered in order to give but a superficial description of the large number of operations which are involved in the construction of even one class of ship and the reasons for the adoption of the methods and operations described. Existing text-books on the subject of naval architecture may be divided into three main classes—(1) theoretical, (2) practical, and (3) pocket-books—each and all of which are designed primarily for the use of students of naval architecture and draughtsmen, and of which the second and third classes are also frequently written with a view to meeting the requirements of ship-owners or their superintendents, and of foremen and the more intelligent workmen. Theoretical text-books form the most numerous class, and this is probably due, in part at least, to the fact that the mathematical principles upon which the science of naval architecture is founded are definite and unchanging, and form a solid groundwork upon which to build the theoretical considerations which govern good design. The multiplication within recent years of technical classes in the large ship-building centres has also contributed to the demand for theoretical text-books for the use of students, and the result has been the publication of numerous works dealing with the subject in all stages, from the most elementary calculations of displacement, &c., to the most advanced work in stability, strength, &c. Except to the comparatively small number of students who take the higher course in naval architecture at universities and technical colleges, the contents of the majority of these books are unknown except through the medium of libraries, as their price puts them beyond the reach of the average apprentice student.

Books dealing with the practical details of ship construction and maintenance are also a fairly numerous class, but it is obvious that a treatise dealing with the practical side of shipbuilding, and making any claim to be exhaustive and up-to-date, must be of considerable size. This is necessary in order to do justice to the very numerous types of vessel and the several systems of construction, and constant revision and extension are necessary in order to bring the book abreast the latest practice. That there is need for a really good work on practical ship construction will be readily admitted by all those who have had experience of teaching this subject, and by no means the least useful function of such a volume is the provision of good drawings showing parts of the structure in their correct relative proportions—it being a matter of considerable difficulty to convey adequate ideas by means of blackboard and chalk. As a handy and reliable guide to the best practice in constructive detail for vessels of an unfamiliar type such books are of great value to draughtsmen and overseers, and copies are now very commonly provided in office libraries for the use of the staffs.

Of the pocket-book class there are comparatively few examples, and these, although extremely popular and handy, are of necessity compelled by considerations of space to deal but superficially, if at all, with practical questions—indeed, it is hardly too much to say that in the vast majority of cases where pocket-books are consulted it is for a table of squares, cubes and roots of numbers, areas and circumferences of circles, or some such purpose.

"Practical Shipbuilding," now under review, belongs primarily to the practical class of text-book, but there has been incorporated in it an indication of the theoretical basis which underlies the constructive design of the ship as a whole and of each of the component parts. In this way a clear indication is given of the functions which each part of the ship's structure is called upon to fulfil in the general scheme of strength and stiffness of the completed ship, and of the comparative merits of various methods of construction from the point of view of mechanically efficient distribution of material. In practice it is very often found that the best distribution of material from the scientific standpoint is far too complicated for economical working or too light to withstand the rough usage to which it may be subjected under service conditions. A compromise must, therefore, be made between the claims of theory and sound practice, and this must be based upon a thorough knowledge of the practical work of construction and of the observed performances of previously built and similarly employed vessels. To a very large extent this special knowledge is supplied by the classification societies under whose supervision merchant vessels are built, and is to a large extent incorporated in their rules, but the tendency of the present day is to specialise types of vessels for specific trades, and this in many cases involves departure from recognised practice in the details of construction. By setting forth clearly the function performed by each item and by means of a series of most excellent figures and diagrams illustrating various forms of construction, Mr. Holms not only makes the reader acquainted with the latest practice, but indicates the lines upon which designs for new or modified constructions to meet special cases should be based.

One of the most striking features of ship design during recent years has been the extent to which the longitudinal system of framing has been adopted for cargo vessels generally, and those designed for the carrying of oil, grain or other cargo in bulk particularly. Mr. Holms has recognised this development to the extent of devoting a new chapter to the consideration of the longitudinal system and comparing it with the different systems of transverse framing at present in use. The types of vessel to which the newer system is peculiarly applicable and the advantages to be gained by its adoption are clearly stated in the text, and appropriate constructions indicated by midship sections of various types of vessel. Other new chapters added to the present edition deal with damage, repairs, and lifeboats and davits. The repair of damage sustained by grounding, collision, &c., as also the work of docking for examination, painting, &c., after the vessel has been in service, is generally regarded as a separate department when undertaken by a firm of shipbuilders, and, whether it is done by builders or repairers, such work, from its nature, and by reason of the hurried conditions under which it has usually to be done, partakes much more of the nature of expedients devised to meet the needs of each case from the practical point of view of speed, economy and efficiency, rather than reasoned conclusions based on scientific principles.

The practical hints given on docking and repair work generally, as also the enumeration of the advantages to be gained by the employment of the oxy-acetylene flame for burning away damaged parts and the employment of the electric-arc welding process for repairs, will prove of especial interest to shipowners and their superintendents and to those engaged directly on repair work, but they should also prove of value to students and draughtsmen whose work is not directly connected with this branch of the shipbuilding industry, and who have therefore little opportunity of becoming acquainted with the work involved and the methods employed.

The chapter on lifeboats and davits outlines briefly the findings of the Boats and Davits Committee, and gives details of some of the means which are now adopted to meet the latest Board of Trade regulations. As Mr. Holms points out, the provision of boat accommodation for all on board is a matter of no small difficulty, and expert opinion is by no means unanimous in approving the principle from the point of view of practicability. The Welin davit, which is described and illustrated in some detail, is perhaps the best known of the patent davits, but a large number of new proposals have been put forward since the Titanic disaster. Some of these, which aim at increasing the area of deck commanded by each pair of davits and increasing the outreach clear of the ship's side, promise well, but they, like all the older types, depend for their efficiency on a moderately upright ship and good weather. On the whole, the possibilities of the life-raft do not seem to have been made the most of up to the present, especially for vessels sailing in moderately smooth waters.

There is probably no part of the subject of ship design which is less generally understood than that of the considerations which underly the assignation of freeboard to any particular ship, and Mr. Holms has done a real service in outlining so clearly the development of the present freeboard tables. The analysis of factors bearing upon the problem, such as dimensions, type of vessel, deck erections and sheer, is full and clear, and in combination with a report of the conclusions of successive Load Line Committees appointed at various times to consider the subject forms a most useful contribution to the subject and enhances the usefulness of the book.

New matter includes notes on oil-carrying vessels, oil fuel, fire extinguishing by means of the circulation of sulphur dioxide, or other gas of similar properties, also watertight subdivision and bulkhead construction. The recommendations of the 1912 Bulkhead Committee, also an analysis of the results of the tests carried out by the Committee on Experimental Bulkheads, are given, together with practical deductions from the results of the tests.

The details of practical construction are complete and thoroughly up-to-date, and include a description of such a comparatively recent innovation as the cruiser stern in merchant work. In connection with the latter one very important advantage of the cruiser stern is not mentioned, viz., reduction of vibration at the aft end due to much greater stiffness in this form of construction. In ships carrying passengers aft this is a very important consideration.

Rivets and riveted work are dealt with in an able manner, but the increasing importance of the pneumatic power-hammer for riveting is hardly adequately recognised, and some limitations in the employment of hydraulic riveting are worthy of note. The employment of the pneumatic hammer in association with an ordinary heavy holding-up hammer for riveting shell and deck work, as well as internal work, has recently been greatly extended—partly, it must be confessed, owing to the scarcity of skilled men—and the results, even in the case of the riveting of the shell in way of oil tanks in light-scantlinged vessels, have been such as to warrant the assertion that this form of riveting will be much more extensively employed in the immediate future. The employment of hydraulic power in riveting oiltight work requires the greatest care in order to ensure oiltight rivets. Many cases have come under the present writer's notice where hydraulically riveted boundary bars on bulkheads were perfectly oiltight as between plates and angles, due to the immense clamping power of the rivets, and yet have given trouble owing to leaky rivets. This trouble arises through the rivet not being crushed straight back into the rivet hole, and thus leaving a pin-hole on one side of the rivet which it may be impossible to detect by casual examination. This tendency to bad work is aggravated by the practice of inserting eight or ten hot rivets at one time and trying to close them all while still hot.

There is no important item, either in steel construction or outfit, which is not described and, in many cases, illustrated in a lucid and convincing form, while the work of the drawing office in designing the form and ordering the necessary material, also the work of the mould loft in laying down the lines and making moulds, templates, &c., is clearly outlined. A short chapter on the strength of beams is of a commendably practical nature, and by its avoidance of the array of mathematical symbols usually associated with such chapters will commend itself to those who habitually skip anything in which such symbols are seen.

As a thoroughly sound and up-to-date treatise on the practical work undertaken in a modern shipyard, from preparing the building berth to the

completion of the fitting-out of all types of merchant vessel, also their subsequent upkeep in the matter of docking, repairs, &c., the new edition of "Practical Shipbuilding" is in the front rank, and is a most valuable and welcome addition to the literature dealing with the practical side of ship construction.

Mathematics for Engineers. (1) *Elementary Mathematics for Engineers.* By Ernest H. Sprague, A.M.Inst.C.E. The Broadway Series of Engineering Handbooks, vol. xxi. London: Scott, Greenwood and Co., 1916. [Price 4*s.* net.]. (2) *Engineering Applications of Higher Mathematics.* By V. Karapetoff. Part II—*Problems on Hydraulics*; Part III—*Problems on Thermodynamics*; Part IV—*Problems on Mechanics of Materials*; Part V—*Problems on Electrical Engineering.* New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. [Price 3*s.* each part.]

(1) For some years past considerable discussion has been raised concerning the range and character of mathematical knowledge best adapted to the requirements of engineers and the methods of imparting that knowledge. We have been passing through a transition stage, in which the course of study and the standard to be attained have fluctuated not a little according to the bent of the particular authority to whom the teaching was entrusted. Some 20 years ago dissatisfaction became acute and reforms were demanded in the manner in which mathematics were taught by the extreme conservative school, who, recognising in those ancient methods an inherent and certain good, which the most radical reformers could not deny, urged the maintenance of a rigorous, inelastic course, that might possibly be to the advantage of the student of pure mathematics, but failed to satisfy the cravings of engineers and practical workers, who looked to mathematical results not as an end in themselves, but as simply providing aids for the logical consideration of problems that came up for solution in actual practice. Mathematical science, it was insisted by the newer school, in its application to engineering might be made to add both to the interest and usefulness of the subject, and many teachers, on behalf of their pupils, welcomed the novel method of handling the tools mathematics supplied. The calculus was no longer a bugbear: it was hailed as a friend and ally. On the other hand, some authorities clung to the belief that engineers were best taught by professional mathematicians perpetuating old methods, on the ground that these led to broader and more exact views, ensuring greater capacity for original investigation. Under the inspiring influence of Professor Perry the victory remains with the new school; professional officialism has been successfully combated, and greater intellectual alertness has been promoted. Teachers enjoy more freedom, and many of the pedagogic dogmas that stifled enthusiasm and impeded progress are now removed.

In studying Mr. Sprague's little book, however, we have an uneasy feeling that the pendulum has swung too far in the opposite direction. He deliberately invites the practical man to be content with a minimum of mathematical information. This was not the intention of Professor Perry and his school. His teaching of applied mechanics and engineering science went hand in hand with practical methods. It was not so much less teaching, or less acquisition of mathematical power, as of a different method of teaching for which the reformers fought. The engineer was not to have fewer tools at command, but a readier way of handling them. The present author advises his pupils to be content with fewer tools. He states that he has left out "many things which are usually included in the standard text-books, but which he has himself seldom or never found a use for." Even within this small compass the author thinks that an improvement might be effected by omitting the few pages devoted to spherical trigonometry, and advises those to whom this subject does not appeal to regard this division as surplusage. It is possible to reduce the old stereotyped methods to too small dimensions, and certainly in some branches of engineering it would be inconvenient not to be able to solve a spherical triangle; and still more so to have to face the career of an engineer with an education as deficient in essentials as this ignorance would suggest.

The pupil has the advantage of beginning on simple arithmetical operations. He is shown how to multiply and divide decimals, but we could have wished fuller directions about the decimal point, for nothing is easier in shortened methods, rightly advocated by the author, than to bring out a result ten times too small or too great. Algebra is pushed to the extent of solving a quadratic equation, and even a cubic is attacked by methods of approximation to find one root. Interest, valuation of property and annuities seem a little out of the engineers' path, and one could have dispensed with this excursion into side issues if the space saved had been devoted to logarithms and the slide-rule, important subjects in which the student's curiosity will be excited without being fully satisfied. Plane trigonometry covers the solution of triangles and the derivation of some useful formulæ. Chapter IV is devoted to mensuration, treated very practically, and might have been usefully extended. After the despised chapter on spherical trigonometry—which is a curiosity in so far that the expression for the cosine of the side of an oblique-angled triangle is not derived, and makes us wonder if this is one of the many things that the author never found a use for—we have a short treatise on algebraic geometry, in which some simple formulæ are derived and problems solved. We could have wished more use had been made of ruled paper for plotting curves, &c., but within the space permitted the treatment is as successful as could be expected. Two short chapters on the differential and integral calculus, respectively, conclude the volume, a few pages being devoted to mathematical formulæ, tables, and data.

The author has not done himself justice because he has not allowed himself space. It was a *tour de force* to attempt to treat the whole mathematical equipment of the engineer in some 180 pages, of which no small percentage is occupied with diagrams and examples. We should imagine that a student after going through this course would be in the same position as one who having learnt something of the Latin Grammar, and armed with a small vocabulary, finds himself face to face with Horace, endeavouring to appreciate the charm of the classic page.

(2) This series of convenient volumes was designed some four years since, when the author issued a collection of problems on machine design. The reception awarded that *ballon d'essai* encouraged and warranted him in producing the four books enumerated above, in which are embodied much of his experience and many of the problems and theoretical extensions that he has found useful in class teaching. The division into small separate treatises is happy. The scheme enables an engineer "who wishes to review calculus or analytics, or to acquire facility in applications of higher mathematics to engineering problems, to select at first the part of the work which deals with problems with which he is most familiar, or in which he is particularly interested."

The author neither belittles nor exaggerates the potency of mathematical reasoning. He knows its usefulness in providing a clear and logical conception of complicated conditions and also its limitations in practice. The teachings of experience, like the results of experiment, cannot be neglected, and many a problem to which mathematics can provide a satisfactory solution has to be modified in practice because conditions are imposed by manufacture, or custom, that cannot be expressed in a differential equation or in the mathematical symbols that define a problem in maxima and minima. The author, however, knows the class he is addressing. He believes there are many who would delight in seeing the pure mathematics they have acquired turned to account, and who would willingly learn how the formulæ they have derived can be applied to practical problems. He quotes with approval the dictum of a French engineer who wrote, "Formulæ are but tools which may guide intelligence, but can never replace it," and this very neatly indicates a safe middle ground between the scoffers who neglect and the advocates who magnify the proper function of higher mathematics in engineering problems.

In hydraulics more than in some other branches experiment has to come to the aid of the pure mathematician. In such fundamental problems as the discharge of liquids from vessels we are accustomed to write the Torricellian equation with an empirical coefficient, and in the theory of liquid jets, to make the actual velocity correspond with the theoretical, it is convenient to employ a coefficient of velocity for which we are indebted to experiment. In problems connected with the hydraulic gradient experimental data are often more accurate than the results of mathematical deduction. If asked to determine the minimum cost of competing plans in a particular construction, a purely mathematical solution is rarely satisfactory, because of the hampering conditions imposed by varying economical considerations. The author treats such deviations when they occur with perfect fairness, and the student should be able to see clearly how far mathematics can assist, and at what point "intelligence" has to be invoked.

In the work on "Thermodynamics" the problems constructed either for illustration or development seem to be less prominent, and the customary appearance of a treatise is more preserved. The references to well-known text-books for proofs of familiar propositions are less frequent, though in the earlier chapters on the expansion of a perfect gas, or saturated steam, we are on fairly elementary ground. The empirical formulæ that have been suggested to express the relationship between the pressure of saturated steam and the corresponding temperature are made the occasion for applying the method of least squares, and, so far as we have tested it, the treatment of non-linear equations appears both novel and useful. Entropy is another subject handled with boldness and originality. There can be few teachers who have not experienced difficulty in approaching this subject, and have perhaps found it convenient to take refuge in mathematical symbols. One of the author's objects is to provide the teacher with additional mathematical problems, and if he is successful in this division of his subject, he will earn their gratitude. But the note attached to the end of the chapter referring to Boltzmann's concept and Planck's further development shows that fresh difficulties are preparing for the pupil, and further opportunities for testing the skill of the teacher. In the last chapter, all too short, on "Heat Transfer in Boilers," a return is made to very practical matters of which a complete mathematical analysis is not yet available.

M. Karapetoff, in another treatise, considers problems that arise in the "Mechanics of Materials," beginning with the strength of beams and the elastic curves these assume under various conditions. Such considerations lead to the fatigue of metals, a troublesome subject to the engineer, but one that presents an opportunity for deriving approximately empirical relations where exact data on *a priori* reasoning are unattainable. Euler's theory of flexure of long rods is the subject of another chapter, satisfactory when the rod assumes a complete half-wave of a sinusoidal curve and compression is left out of the problem. Empirical and semi-empirical formulæ again come to the engineer's aid when Euler's formulæ do not apply and it is necessary to determine approximately the strength of columns of medium length. Some of these formulæ are discussed as "examples of reasoning by which practical problems are solved approximately when the true physical relations are too complicated." In the last chapter, on the strength of thick cylinders and spheres, where it is necessary to trace the distribution of stress, the same method of attack is followed. A gradual development is noticeable in the theory, by which crude fundamental assumptions are gradually improved and brought nearly into line with practical conditions.

The student would not expect that such solutions as he arrives at here, or in the subject of "Electrical Engineering," the last of the treatises, would enable him to handle with confidence and certainty practical projects in their complexity. We are rather concerned to point out that the subjects brought under discussion involve a fairly wide outlook and are typical of many others that might be adduced. The reasoning should appeal to the mathematically trained student. He has the opportunity of applying or widening his knowledge: a process that should constitute both the charm and the usefulness of the series. In one's work at times it is invitingly convenient to leave an integral in its symbolical form, and to forget to inquire whether it can be integrated, or what assumption must be made to

permit the operation. Similarly, the constants introduced by integration are often not regarded as of great practical importance. The thoroughness with which the author pursues such details is welcome, as evidence of good teaching.

BOOKS RECEIVED.

United States Coast and Geodetic Survey. Department of Commerce. Serial No. 33. *Results of Observations made at the United States Coast and Geodetic Survey Magnetic Observatory at Vieques, Porto Rico,* 1913 *and* 1914. Serial No. 36. *Results of Magnetic Observations made by the United States Coast and Geodetic Survey in* 1915. By DANIEL L. HAZARD. Washington: Government Printing Office.

Department of the Interior. Bureau of Mines, U.S.A. Technical Paper 102. *Health Conservation at Steel Mills.* By J. A. WATKINS. *Technical Paper* 117. *Quantity of Gasoline Necessary to Produce Explosive Conditions in Sewers.* By G. A. BURRELL and H. T. BOYD. *Technical Paper* 121. *Effects of Temperature and Pressure on the Explosibility of Methane-Air Mixtures.* By G. A. BURRELL and I. W. ROBERTSON. *Technical Paper* 159. *Production of Explosives in the United States during the Year* 1915, *with Notes on Coal Mine Accidents due to Explosives, Lamps and Motors.* Compiled by ALBERT H. FAY. *Technical Paper* 145. *Sensitiveness to Detonation of Trinitrotoluene and Tetranitromethylanilin.* By GUY B. TAYLOR and WILLARD C. COPE. *Technical Paper* 161. *Construction and Operation of Single-Tube Cracking Furnace for Making Gasoline.* By C. P. BOWIE. Washington: Government Printing Office.

The Royal Navy List, or Who's Who in the Navy. A Book of Reference relating to the personnel of the Navy, both Active and Retired, together with a Summary of Services and Commissions, Special War Supplement containing Services and Honours of Officers, Diary of Naval Events, Battle of Jutland Dispatch. Founded in 1878 by the late LIEUT.-COLONEL FRANCES LEAN, R.M.L.I. London: Witherby and Co. [Price 10*s.* net.]

The Electrical Engineers' Diary, 1917. *For the use of Consulting Engineers, Electrical Contractors, Central Station Engineers, and all users of Electrical Apparatus.* Edited by J. H. JOHNSON, M.I.E.E. London: S. Davis and Co., 20 and 31, Great Swithin's-lane, Bank, E.C. [Price 5*s.*]

University of Illinois Bulletin. Engineering Experiment Station Bulletin No. 91. *Subsidence Resulting from Mining.* By L. E. YOUNG and H. H. STOEK. Urbana: Published by the University of Illinois; London: Chapman and Hall, Limited.

University of Illinois Bulletin. Water Survey Series No. 12. *Chemical and Biological Survey of the Waters of Illinois. Report for Year ending December* 31, 1914. EDWARD BARTOW, Director. Urbana: Published by the University of Illinois. [Price 1.25 dols.]

The Principles of Electric Wave Telegraphy and Telephony. By J. A. FLEMING, M.A., D.Sc., F.R.S. Third Edition (fully revised and extended). London: Longmans, Green and Co. [Price 30*s.* net.]

Munro's Marine Engineers' Annual, Pocket Log and Diary, 1917. Compiled and Arranged by JAMES K. MUNRO. Glasgow: James Munro and Co., Limited. [Price 1*s.* net.]

The New Hazell Annual and Almanack for the Year 1917. By T. A. INGRAM, M.A., LL.D. London: Henry Froude and Hodder and Stoughton.

Some Modern Methods of Ventilation, with Special Reference to Public Buildings. By R. GRIERSON. London: Constable and Co. [Price 8*s.* 6*d.* net.]

The Administration of Industrial Enterprises, with Special Reference to Factory Practice. By EDWARD. D. JONES, Ph.D.

The High Price of Sugar and How to Reduce it. By HAROLD HAMEL SMITH. London: Bale, Sons and Danielsson, Limited. [Price 1*s.* net.]

Jane's Fighting Ships, 1916. *An Encyclopedia of the Navies of the World.* London and Edinburgh: Sampson Low, Marston and Co., Limited. [Price 21*s.* net.]

Practical Safety Methods and Devices: Manufacturing and Engineering. By GEORGE ALOIN COWEE, E.M., S.B. London: George Routledge and Sons, Limited. [Price 7*s.* 6*d.* net.]

Peaceful Penetration. By A. D. MCLAREN. London: Constable and Co., Limited. [Price 3*s.* 6*d.* net.]

Functions of a Complex Variable. By THOMAS M. MACROBERT, M.A., B.Sc. London: Macmillan and Co., Limited. [Price 12*s.* net.]

Modern Gasworks Practice. By ALWYNE MEADE, Assoc.M.Inst.C.E., with an Introductory Note by STANLEY H. JONES, M.Inst.C.E. London: John Allan and Co., *The Gas World* Offices, 8, Bouverie-street, E.C.

Sea Power. By ARCHIBALD HURD. London: Constable and Co., Limited. [Price 1*s.* net.]

The Motor Car: What it is, and how to drive it. By T. O. A. LAWTON and R. J. HARVEY GIBSON. London: Edward Arnold. [Price 1*s.* net.]

CANADA'S NICKEL OUTPUT.—The value of the nickel production of Canada in 1916, says *Canadian Machinery*, is estimated at 23,000,000 dols., against 20,423,348 dols. in 1915 and 13,655,381 in 1914. Ten years ago the valuation was 8,948,834 dols., and in 1896 it was 1,188,990 dols., and only 498,286 dols. in 1889. In the first half of 1916 the output was 42 per cent. greater than for the corresponding period of 1915.

GREAT WESTERN RAILWAY DEVELOPMENTS IN BIRMINGHAM.

(*Continued from page* 51.)

Electrical Machinery for Handling Goods.—The high-level goods yard deals principally with perishable market traffic, and, after that has been disposed of, with general traffic. Low-level shed A was designed chiefly for metal traffic, and shed B for market and general traffic. All goods carried by rail to or from the low-level sheds A and B must be either lowered from or raised to the high-level yard, and this fact dominates the design of the machinery provided to deal with it.

The machine still most commonly used to aid manual power in transferring goods to or from a railway wagon is the jib crane. Primarily a manual machine, the jib crane, where the amount and weight of the work it has to do justifies the cost, has developed into a power-worked machine, the power being either steam, hydraulic or electric. The usual type of jib crane is a fixture in the yard or on the platform of a goods shed, and consequently the wagon to be loaded or unloaded has to be brought to the crane.

The tendency in the development of goods-handling machinery is to bring the loading or unloading machinery to the wagon, and, in general, the saving in time by this process is all-important. The special conditions of high and low level at Moor-street limit the application of this principle to a degree unusual in a modern goods station.

All the machinery in these goods sheds and yard is driven electrically. A three-phase high-tension supply is taken from the Birmingham Corporation at a periodicity of 25, and is transformed to 440 volts between phases. It is used at this pressure in all the machinery described hereafter, with the exception of the semi-automatic switch-gear for the lifts, where the single-phase lighting supply at 220 volts is used for exciting the solenoids.

Dealing first with the high-level goods yard, designed primarily to deal with perishable market traffic, and only after this has been done with general traffic, the covered goods shed in the yard comprises under one roof two long sidings, a platform beside one of these sidings, and a cart road between the platform and the other siding. The platform and the siding beside it are served for a length of 400 ft. by an overhead travelling crane made by Messrs. Royce, Limited, of Manchester (Fig. 16, Plate IX, in our issue of January 19). The travelling bridge, with a span of 28 ft. 4½ in., moves at an average speed of 250 ft. per minute and carries a traversing carriage with an underhung revolving jib below it, the jib having a radius of 16 ft. The carriage with its jib traverses the shed at a speed of 70 ft. per minute, while the jib revolves at a speed of 2 r.p.m., and the hoisting gear raises and lowers a load of 1 ton at an average speed of 33 ft. per minute. The combined action of travelling the bridge, traversing the carriage with its jib and sluing the latter can take the load to or from any wagon in the siding, or from or to any cart in the cart road, the jib passing between the roof-supporting stanchions. The jib is controlled by a pedal brake and the sluing gear contains a friction clutch, which gives if the jib is by accident slued against one of the roof stanchions. Two covered openings in the shed platform are provided through which, when the covers are removed and the opening guarded, goods in special crates can be raised from or lowered to the low-level sheds A or B. The electrical equipment was made by the British Westinghouse Company.

South of the high-level shed and just outside it is a fixed jib crane capable of raising and lowering a load of 6 tons. The gear can raise and lower its full load at a speed of 20 ft. per minute and slue it at a speed of 2 r.p.m., the jib radius being 15 ft. An automatic electric brake is fitted to the hoisting gear, while provision is made for lowering either by a separate hand-lever brake or by the use of the motor itself as an electrical brake. This crane was made by Messrs. Stothert and Pitt, Ltd., of Bath, the Electric Construction Company providing the motors and Messrs. Allen West, of Brighton, the controllers and resistances.

For marshalling the goods wagons, which are raised from or lowered to the low-level shed B by the 30-ton lift (referred to hereafter), the north-east end of the yard is provided with a 25-ton bridge traverser (Fig. 19, page 98, which also shows the roof of the high-level goods shed and the motor-house of the 30-ton lift). The traverser is designed to transfer wagons between three parallel lines of rails, the wagon being hauled on to or off from the traverser by an electric capstan. The rails on the traverser are extended at either end as spring ramps. The design provides for the least possible interference with the permanent way, the rails of the sidings being only notched to allow the single flanges of the outside traverser wheels to pass. The traverser, made by Messrs. Ransomes and Rapier, of Ipswich, and of their standard design for this class of work, is hauled by two endless steel ropes running in grooves below rail level. These ropes, turned through a right angle by sheaves, take several turns round a drum worked through worm and spur gearing. This gearing is driven by a Westinghouse electric motor. Fig. 19 shows the controller at the end of the motor-house. The sheaves at the far end of the rails on which the traverser runs can be moved to tighten the ropes.

Thirteen Clyde capstans and a large number of reels are disposed in the yard to haul wagons, either singly or in trains, to and from the 20 and 30-ton wagon lifts, the 6-ton crane, the long siding beside the covered platform, and two turntables at the Moor-street end of the yard. Each capstan barrel has its rope permanently attached to it. The barrel is free to revolve unless the hand lever is pulled over. This motion of the lever puts in a clutch connecting the barrel to the worm and spur gearing necessary for reducing the speed of the electric motor. The same movement of the hand lever which puts in the clutch closes a switch which starts the motor. The switch contacts make and break under oil, and the motor is an ordinary squirrel-cage induction motor not capable of exerting the necessary torque to start the load unless it is running near synchronous speed. Consequently between the motor and gearing an automatic centrifugal clutch is provided which does not grip until the motor has attained sufficient speed to exert the necessary torque, which, when wagon trains of 200 tons are hauled, may exceed 200 per cent. of the rated full-load torque of the motor. The centrifugal clutch is a most economical arrangement for preventing prolonged peak loads upon the supply, since in the five or six seconds during which the rotor is running up to near synchronous speed it stores enough kinetic energy to start the train of wagons without taking more electricity, after the centrifugal clutch grips, than is required to pull the wagons at the rated speed. For working single wagons on to or off from a turntable and for turning the table less power is required, and this is secured by making the switch connect the motor first in star and afterwards in delta. The star connection is alone required for turntable work, and a notch in the hand-lever guide is provided so that by means of the spring catch on the lever the latter can be held in the star position.

Only some of the capstans at Birmingham are provided with star-delta switches. In the others the motors are connected in delta straight away. The rope used on a Clyde capstan is never handled by the capstan man except to unwind it from the barrel and haul it to the wagons, which can be done by the hook. This allows steel ropes to be used instead of hemp ropes, which latter must be used where the rope slips on the barrel and the capstan man hauls in the slack. The consequent saving in the annual cost of ropes and in the labour of handling hemp ropes when wet is remarkable, while there is also less risk to the operators due to rope breakages. All these capstans have been made by Messrs. Stothert and Pitt, and the switch gear by Messrs. Morris and Lister. The squirrel-cage motors were provided by the Electric Construction Company, Star-connected, the capstans can exert a pull of 500 lb., and delta-connected 1,400 lb., at 200 ft. a minute, or 3,500 lb. at 165 ft. per minute.

In the low-level sheds A and B there are 14 similar capstans, 4 in shed A to serve the 30-ton lift and traverser and the sidings, and 10 slower speed capstans in shed B, where the number of sidings is

THE MOOR-STREET GOODS STATION, BIRMINGHAM; G.W. RAILWAY.

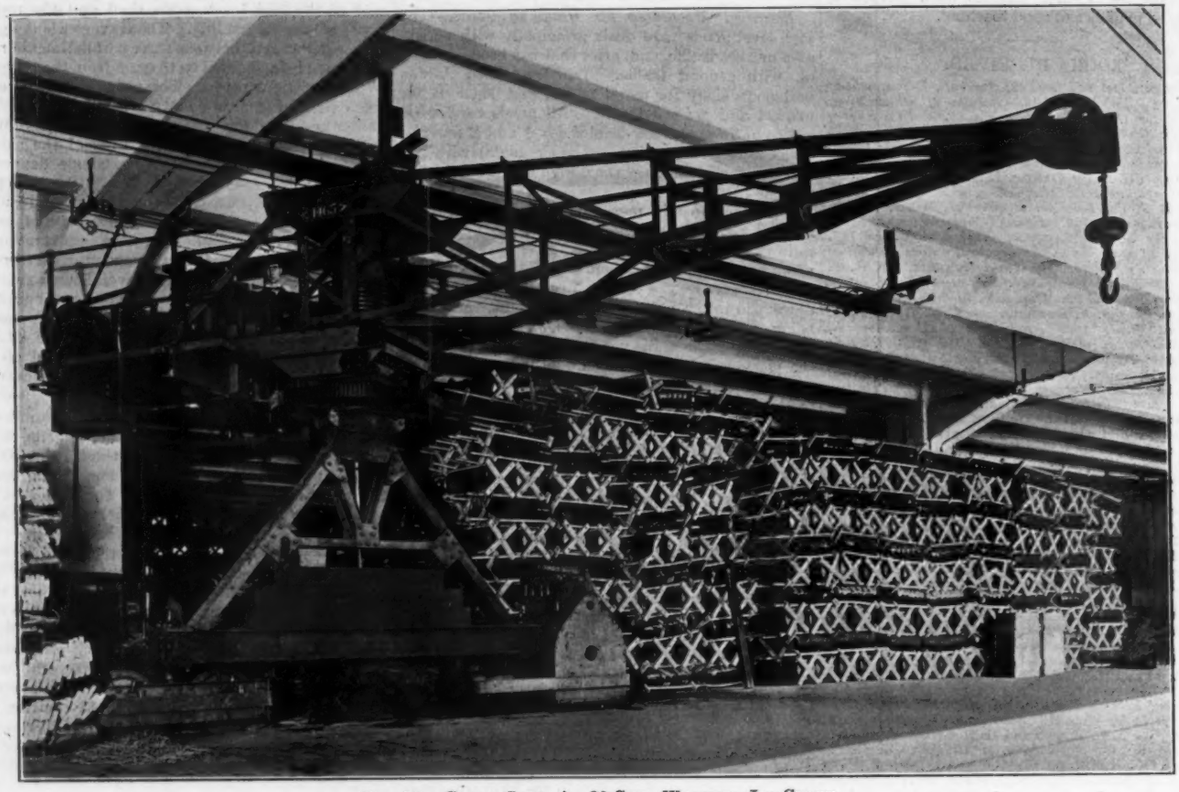


Fig. 18. Goods Shed A; 30-Cwt. Walking Jib Crane.

greater. All the necessary reels for guiding the capstan ropes are provided. The electric equipment for the capstans in shed B was provided by Messrs. Crompton and Co.

Shed A contains only two long sidings for which power appliances are needed. Between the sidings, which run for a distance of 285 ft. at right angles to the cart entrance from Park-street, are two platforms, one beside each siding, and a broad cart road between the platforms. A cross platform at the Moor-street end (farthest from the Park-street entrance) connects the two long platforms, the whole forming a U-shaped continuous platform. The inconvenience of fixed jib cranes, which occupy valuable platform space, and to which the wagons must be brought, has been already insisted on. Consequently a walking jib crane has been provided which runs on a one-rail U-shaped track extending down each platform forming the legs of the U and round the cross platform. Fig. 18 shows this crane at the extreme end of its travel on one platform. The crane hoists and lowers its full load of 30 cwt. at a speed of 40 ft. per minute, and slues the jib at a speed of 2½ r.p.m. A friction clutch allows the jib to slip if it is slued into one of the piers. The structure is carried by two swivelling trucks, which run on a 70-lb.-to-the-yard bridge rail recessed into the platform, the radius of the curve connecting the two straight runs being 34 ft. 4 in. The top of the structure is guided by rollers between the flanges of a rolled steel joist fixed to the ferro-concrete roof beams. The crane travels at a speed of 250 ft. per minute on the straight, and the jib radius of 18 ft. allows of anything within reach on either platform being transferred to a cart backed against the platform or *vice versa*. The crane, and top guide with its three conductor wires, was made and erected by Messrs. Babcock and Wilcox, the motors were provided by Messrs. Harding, Churton and Co., and the controllers by Messrs. Allen West and Co.

A 30-ton lift is provided in each of the sheds A and B to transfer wagons between the high-level yard and each shed. Fig. 21 shows that part of the lift structure which is on the high level; the lift in the foreground serves shed B and that in the background shed A. In both lifts the cages are shown at top level. These lifts are similar in all respects except the height of lift, and this description applies to both. In the lift for shed A the distance between rail level in the yard and the shed below it is 24 ft. 1½ in. The cage can take a wagon 25 ft. over buffers and weighing 30 tons, and, on test, such a wagon has been raised and lowered at an average speed of 128 ft. per minute. Fig. 20 shows the hoisting and lowering gear in the motor-house shown in Fig. 21. A steel wire rope is attached to each bottom corner of the cage and is wound on a grooved cast-iron drum. The weight of the cage and of half the 30-ton load is counterbalanced by two sets of weights in removable sections working on guides in the lift structure and carried by ropes coiled on the same drums as the hoisting ropes. Each pair of opposite drums is driven through single-reduction gearing by a shaft, the two shafts being coupled together through bevel gearing, as shown on Fig. 20. On each of the driving shafts a worm-wheel is mounted,

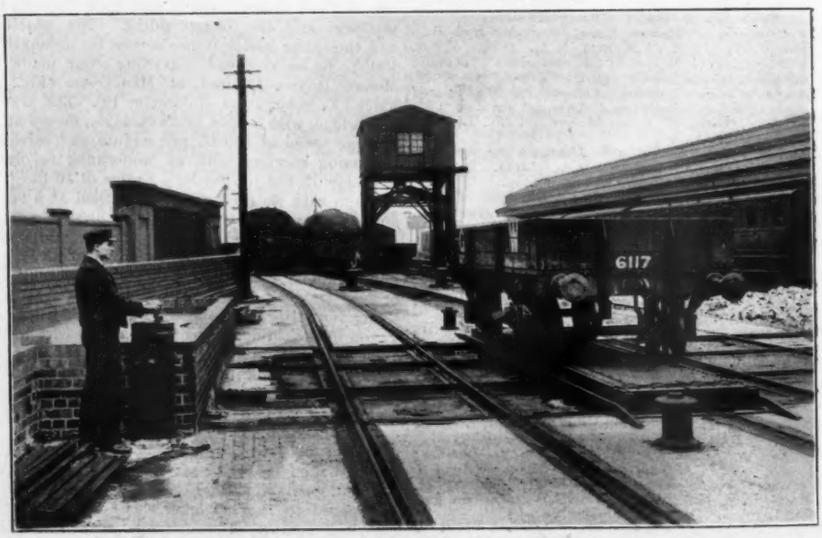


Fig. 19. High-Level Yard; 25-Ton Bridge Traverser.

THE MOOR-STREET GOODS STATION, BIRMINGHAM; G.W. RAILWAY.

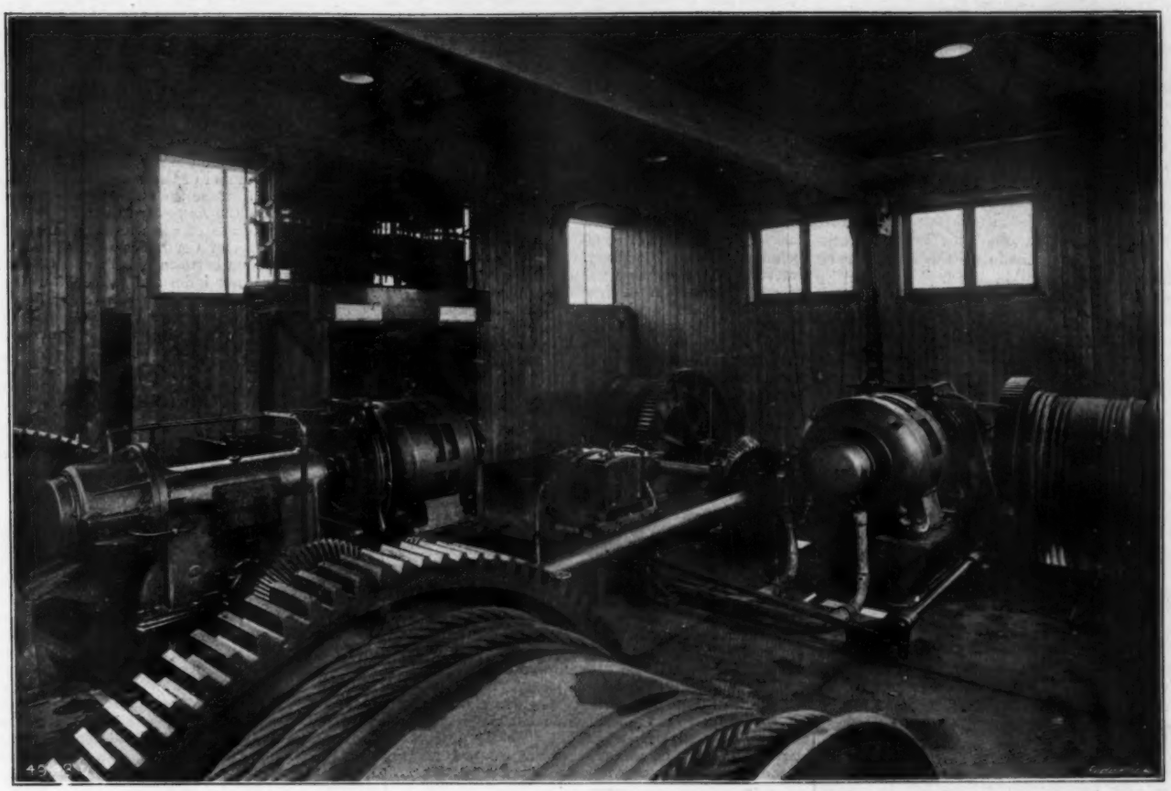


FIG. 20. GOODS SHED A; HOISTING MACHINERY FOR 30-TON LIFT.

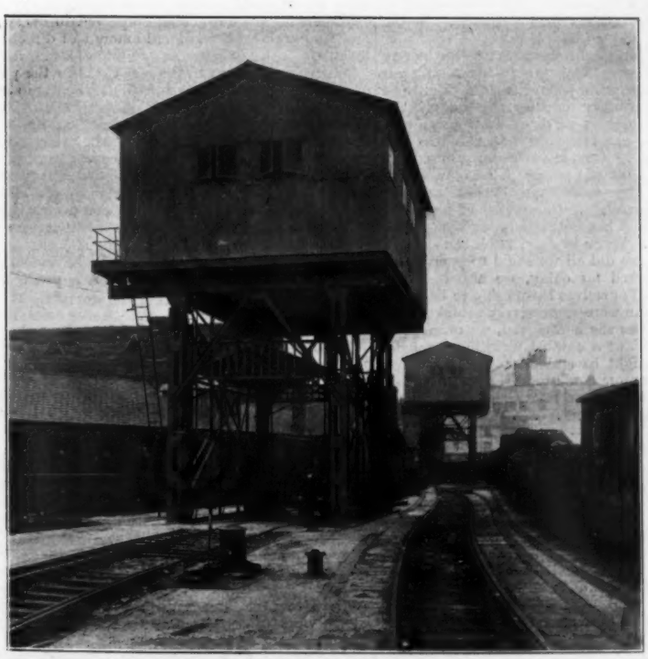


FIG. 21. HIGH-LEVEL YARD; 30-TON LIFTS SERVING SHEDS B AND A.

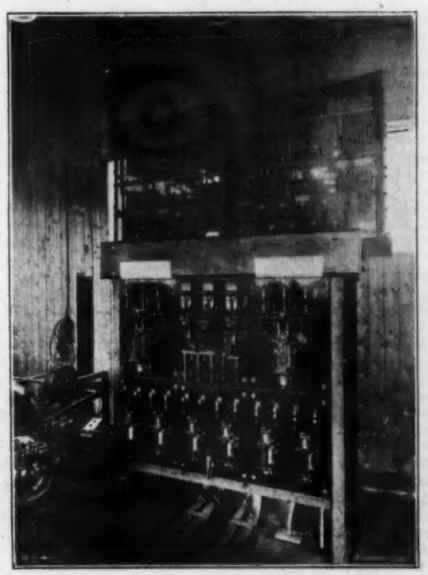


FIG. 22. SHED A; ELECTRICAL SWITCH-GEAR TO 30-TON LIFT.

driven by a worm coupled direct to an induction motor with wound rotor. Each of these two motors is rated at 120 h.p. At starting, when lowering the empty cage (*i.e.*, lifting the counter-weight) or when raising the full load of 30 tons, the input to the pair of lift motors is 420 kw. The lifts were made by Messrs. S. H. Heywood and Co., of Reddish, the three-phase motors being provided by the Lancashire Dynamo Company and the semi-automatic switch-gear by Messrs. Electric Control, Limited, of Glasgow. This switch-gear is shown on Fig. 22 and consists of contactor switches moved by alternating-current solenoids. The top centre panel contains an overload circuit breaker with no volt release, and the main and control hand switches. On either side is a panel with a cage-direction switch (up or down) connecting the stator to the supply. The

lower row of switches comprises the rotor starting and short-circuiting switches, three for each motor.

The rotor resistances are seen above the switchboard. Three-phase automatic brakes, one for each motor, are provided, and the pair of brake magnets are shown clearly in Fig. 20, as well as one of the brakes on the motor spindle. To provide easy adjustment of the brakes so as to ensure both coming on together, the two magnets have been brought to the middle of the floor and coupled together, their combined pull being transmitted through links and way shafts to the brakes. When the empty cage is going up, the descending counterweight of over 20 tons tends to drive the motors above synchronous speed as alternators and generate electro-motive force. In case this proved inconvenient, provision was made at the end of each worm-shaft for an absorption disc-brake worked by the thrust of the worm. Autographic records of the input to the motors, however, show that current under the above condition is returned to the supply, but to so small an extent as to be not worth considering and the thrust brakes have not been fitted.

The switch-gear is worked by means of a master controller in the cage. Its handle is interlocked with disappearing rail stops on the cage rails. The controller handle cannot be moved until the rail stops have been raised, after the wagon is in position, to prevent its movement either way in the cage.

Exact alignment of cage rails and siding rails at top or bottom can rarely be found by the hand-worked master controller, and raise and lower inching buttons are provided in the cage which, when pressed, move the cage the necessary amount up or down with all the resistance in the rotor circuit.

Other safety devices consist of automatic gear to hold the cage should any of the ropes break or stretch unduly. Limit switches are provided to prevent over travel of the cage either at the top or bottom. These act first on the control gear, and should this fail a second switch cuts off the main supply.

(To be continued.)

INDUSTRIAL NOTES.

Under the powers conferred upon him by the Labour Exchanges Act, 1909, and in concurrence with the Ministry of Munitions and the Director of National Service, the Minister of Labour has appointed a committee for the northern portion of the West Riding of Yorkshire to advise and assist the Ministry in connection with the substitution and reinforcement of labour. The committee consists of representatives of employers and workmen in equal numbers, together with representatives of local authorities and Tribunals. The offices of the committee will be at Leeds. The chairman is Mr. Geoffrey Ellis, J.P., and the secretaries are Mr. A. N. Mason, of the Employment Department of the Ministry of Labour, and Mr. F. M. Box.

The Minister of Munitions again calls the attention of all persons who have copper scrap in their possession to the Order published in the *London Gazette* on January 2, and reminds them that the penalties provided by law will be enforced in all cases where returns of such material are not made as directed in the Order. The Order includes all scrap copper, other than such as is specifically excepted, and applies to such articles as old copper, calico printer's rollers, old copper plates used in printing, and other similar forms of copper, as well as to turnings, swarf, &c. All returns should be made within seven days after the close of each month. The Ministry states that the buying prices for scrap copper set out in the schedule to the Order published on January 2 are net, and include the cost of packages, which must be provided by the seller. Delivery must be made f.o.r. to the nearest station unless otherwise arranged with the Ministry. Consignors must themselves arrange with consignees for the return of their packages.

The Minister of Labour, writing on January 29, stated with reference to the Labour Exchanges, that 2,063,813 women registered at them last year and 765,481 were placed in employment. An average of 2,766 women were placed in employment through the exchanges every day last month. Further, in response to an appeal made by the President of the Board of Trade and the Home Secretary in March, 1915, nearly 100,000 of all classes of society registered themselves on a special war register at the Exchanges for war work. "I have said publicly, and I adhere to it," added the Minister, "that there is room for improvement in the Exchanges, and I mean to make that improvement. But while the Exchanges have not, in my opinion, done as much as they might have done, largely due to employers not having made to the Exchanges the demands for women's labour that they might have, yet, as the above figures show, they have accomplished a great deal of very useful work. It is my desire to extend and improve this work, but this cannot be accomplished by prejudicing the public against the machine or ignoring its existence."

In the course of the proceedings on Thursday, January 25, of the sixteenth annual conference of the Labour Party, a resolution from the Independent Labour Party asking for an International Socialist Congress to be held simultaneously with the Peace Congress was defeated by 1,498,000 votes against 696,000, a majority of 802,000. A proposal, made on behalf of the Socialist Party, to the effect that the best interests of the working classes would be served by a speedy termination of hostilities, was defeated by 1,697,000 votes against 302,000, a majority of 1,395,000. A resolution by Mr. W. Thorne, M.P., which said that "Seeing the invasion of Belgium and France by the German armies threatened the very existence of independent nationality and struck a blow at all faith in treaties, the conference agreed that the war should continue until victory was achieved, and that the socialist and trade union organisations of the Allied Powers should meet simultaneously with the Peace Congress," was passed by 1,036,000 votes against 434,000, a majority of 602,000. Resolutions were also passed dealing with the conscription of wealth, advocating economic equality between men and women employed in industry, and with the scale of pensions to sailors, soldiers and their dependents. The conference concluded its proceedings on Friday, January 26, by the passing, among others, of a resolution against the employment of black labour in this country.

A deputation from the Executive of the Triple Industrial Alliance (Miners' Federation of Great Britain, National Union of Railwaymen and National Transport Workers' Federation) called on the Prime Minister last Tuesday, with reference to this question of the importation of black labour. The Prime Minister assured the deputation that there was no present intention on the part of the Government to introduce in this country indentured coloured labour.

Major W. A. Chapple, M.P. for Stirlingshire, has written to the Independent Labour Party refusing his support to the latter's proposal to urge Government to enter into peace negotiations with Germany. In the course of his letter Major Chapple says:—"Germany designed, prepared for, and consummated this bloody raid upon mankind with no other justification than the lust of power, the pride of an insane egoism, and the desire to use a military machine she thought she had brought to the highest pitch of destructive perfection. Before the war Germany was free to trade and travel anywhere. Our navy never abused its power. We never built a port or policed an ocean route that was not as free to Germany and on the same terms as it was to ourselves. Germany had no legitimate complaint against her neighbours, or against us, or against the world. When in July, 1914, she showed her claws and teeth, we did all we could to pacify and restrain her. We asked for delay, we urged a conference, we humiliated ourselves by offering to befriend her if in the future she were aggressively attacked, we appealed to the treaties she had signed, we even wore designedly the aspect of a coward unwilling to help France lest Russia might be emboldened to some act of aggression. What more could mortal man or nation do? We had to defend our country and our honour or die—and worse, deserve it. . . ."

Speaking on Friday, January 26, at a dinner of the Executive Council of the Associated Iron and Steel Workers of Great Britain, held at Manchester, Mr. John Hodge stated that the war had demonstrated to this nation that the iron and steel trade was a basic industry. Without iron and steel we would have been lying at the feet of Germany to-day. The war had also taught us lessons in political economy. Fifteen millions of new capital had been expended in the extension of plant in the iron and steel trades, and the thought which had come in his mind was as to whether that capital was to lie idle when the war was over. The capital would probably be thirty millions when the war was over instead of fifteen. If that plant was going to lie idle it would become unprofitable. Capital wanted interest on its expenditure. If it could not make interest wages were going to suffer. He did not care whether it was by tariff, prohibition, Government bounty, or any other method, but the plant in our country must be utilised.

An interesting booklet by Mr. Herbert W. Jordan deals with the Registration of Business Names Act, 1916, and sets out the requirements of the Act. It is issued at the price of 6*d.* net by Messrs. Jordan and Sons, Limited, 116 and 117, Chancery-lane, W.C. It gives the history of the Act, and states that when our country entered into the present war general regret was felt that no machinery had been provided by Statute rendering it incumbent upon those engaged in business to disclose their identity. The Act sets matters right in this respect, and the booklet explains in detail the steps to be taken to conform with its provisions.

At a meeting at the Cutlers' Hall, on January 29, of the Sheffield Chamber of Commerce and Manufactures, it was decided to place the following resolution before the gathering of the Associated Chambers:—

"That immediate efforts should be made by the various Chambers of Commerce to assist in bringing about co-operation between Labour and Capital, with a view to assuring industrial peace after the war; towards this end, conferences between employers and employed should be arranged by the Chambers for the purpose of discussing the best means of increasing the productive capacity of the country."

A resolution was also passed to the effect:

"That the Trade Bank referred to in the report of Lord Faringdon's Committee should ascertain and conduct a scheme of insurance on the lines of Lloyd's marine insurance which would enable British traders to insure against the risks of unpaid bills of exchange and unpaid accounts relating to overseas trade with customers approved of by that bank."

The List of Certified Occupations, dated November 20, 1916, has been revised, with a view to releasing more men for the Army. The new List (R. 117) and a statement (R. 118) show the principal alterations which have been made. The chief alteration introduced is the removal from the List of men classed as B1 (garrison service abroad) who fall below the age limits stated in the List. The age limits for married men have been very generally raised, usually either from 25 to 27 or from 31 to 33; larger advances have been made in a number of cases. In many occupations the age limit for single men is 41 years; single men in these occupations are in a certified occupation only if they are in lower medical categories than A or B1. Where the age limit for single men is not 41 years, generally the trade is a munition trade or some other trade of vital national importance, or the occupation is that of foreman, an occupation which has become more essential on account of the large number of substitutes who are now being employed in every trade, and who need an exceptional amount of direction and training.

Attention is drawn to the fact that, for the purposes of the List of Certified Occupations, the ages stated in the List are the ages of men on April 4, 1916 (except in the case of agriculture, for which the date is May 1 for England and Wales, and May 31 for Scotland). A man who had on April 4, 1916, reached the age stated in the List is in a certified occupation, irrespective of his medical category; men under those age limits are entitled to be treated as in a certified occupation only if they are not passed as fit for general service or for garrison duty abroad (category A or B1).

By a notice given another List will be issued in the course of a few weeks, by which it is hoped to release more men for the Army.

The Minister of Munitions announces that he has made further Orders under the Munitions of War Acts, 1915 and 1916, under which 97 additional establishments have been declared controlled establishments. The total number of controlled establishments is now 4,719.

A statement has been issued by Mr. Finlay A. Gibson, secretary of the Monmouthshire and South Wales Coalowners' Association, dealing with the action of the Government in calling up more miners for military service. It states that whilst the coalowners do not wish to interfere with such military measures as the Government may consider necessary in the national interests, and whilst, further, they are prepared to place at the disposal of the Government any services of which their organisations and their local mining knowledge are capable, they view with apprehension the enforcement of arrangements made by the military and Home Office authority without any consultation with those to whom the State looks for the maintenance of the coal production of the country. This subject was dealt with in a meeting held a few days ago at the Home Office, London, when representatives of the coalowners and of the men attended. We understand that the Home Office has promised to go more fully into the question, together with the other Government Departments concerned, and that a communication will be issued in due course.

ITALIAN ELECTRIC RAILWAYS.

(*Concluded from page* 79.)

SECTION insulators are used at the change-overs and in the stations, where the system is protected by buffer sections, *i.e.*, short lengths of aerial contact line supplied by independent feeders from which the current can be shut off, the conductors of each phase being sectioned at the ends of the track by means of the section insulators. The use of these insulators is being gradually extended in the electrified systems carrying a large traffic, having a large developed length of main and branch lines and important crossings owing to the necessity of being able to isolate a section in which a breakdown has occurred without interruption in the service at other parts of the system. The section insulators are made of highly resistant wood treated in a special way so as to maintain for a long time both good mechanical strength and high insulation. The simple change-overs contain two or three section insulators; the line (English) crossings contain at least six (see Fig. 10). There are four section insulators in each buffer section for each track. Fig. 11 is a diagram of a system for an intermediate station with buffer sections. On the feeders of the latter are inserted two automatic cut-outs. Fig. 12 is a diagram of circuit in Modane station.

Fig.10.

Fig.11.

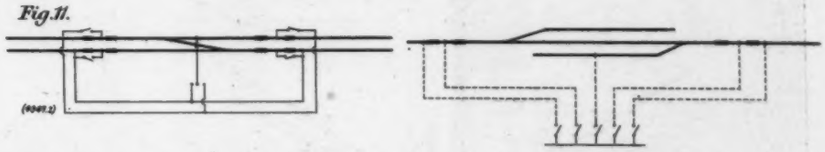
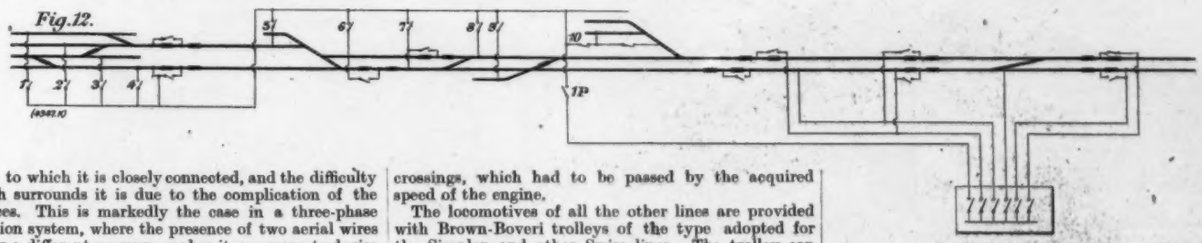


Fig.12.



Aerial Crossings.—The problem of providing the aerial crossings is no less important than that of insulation, to which it is closely connected, and the difficulty which surrounds it is due to the complication of the devices. This is markedly the case in a three-phase traction system, where the presence of two aerial wires under a different pressure makes it necessary to devise special means to prevent short-circuits between the aerial phases and to guarantee at the same time continuity in the supply of the motors. The experience gained with the catenary suspension on the Lecco-Calolzio track of the Monza-Lecco line showed the necessity of adopting a very simple suspension for the three-phase frog, with a view to reducing the number of live wires, insulators, &c., and thus to reduce the causes making for interruption. The English crossing used on the track in question contained quite 36 section insulators of wood; the weight of the device was very great, and it was found difficult to maintain this latter in perfect working order.

The crossing for a railway has to satisfy very many requirements, several of which have not so far been met to perfection. Limiting the present remarks to three-phase lines only, it may be stated in the first place that the wires have to be mounted so as to prevent short-circuits between the two aerial phases even when the collector undergoes notable transversal oscillations, oscillations which are due to the swerving of the engine at the passing of a crossing at a high speed. The number of insulators has to be reduced to a minimum, one reason being not to render excessive the weight of the apparatus, which is large in itself. Uniformity in the tension of the wires must be kept up for a long period. The suspension has to be sufficiently strong to reduce to a minimum the oscillation of the whole aerial system, although it is to some extent inevitable under the action of the wind.

There are portions of the Italian lines in which the switches and crossings are very numerous, and at these parts the aerial system forms a most complicated accumulation of wires and insulators, which, seen from a distance, have the appearance of a metallic platform. The system at these places is protected by double-tension automatic cut-outs. In past years, owing to the repairs which were constantly required, the trains had frequently to run beyond some of the crossings by their acquired speed and with the trolley lowered. At the present time, also, some drivers are careful to insert the resistance in the secondary of the motors when passing the crossings, although there is no further reason to fear serious disturbances at crossings, since this important feature of three-phase electric traction now seems to be satisfactorily solved, even in the case of heavy and high-speed traffic.

Before referring to the various types of aerial electric crossings in service on the Italian lines, a few words on the current supply to the motors of the three-phase electric locomotives will be found of interest, this having a particular bearing upon the design of the crossings.

The first locomotives of the Valtellina railway were provided with roller current collectors, fitted with ball bearings. Each of the two trolleys could act in one direction only, hence the running was affected by one collector alone. The trolley was insulated from the top of the locomotive, and the rods of the supporting frame acted as conductors for the current supply to the motors. The pressure against the contact wire was 8 kg. (17¾ lb.). The presence of one single trolley greatly simplified the design of the aerial crossings and required the use of section insulators only in the buffer sections. On the other hand, it was necessary to switch out the motors when running under the section insulators and under the aerial crossings, which had to be passed by the acquired speed of the engine.

The locomotives of all the other lines are provided with Brown-Boveri trolleys of the type adopted for the Simplon and other Swiss lines. The trolley can work in both directions of travel. Its framing is connected directly with the mass of the motors; there are four current collectors (see Figs. 13 and 14, page 102), two for each phase, connected with the inside of the locomotive by insulated and protected cables. The collectors of each phase are electrically connected together. The contacts are of the gliding type, of brass, and 2 to 3 mm. (0·078 to 0·118 in.) thick. It is obvious that in order to obtain continuity in the current supply it is sufficient that one alone of the two collectors be in contact with the live wire. It is therefore sufficient that the tract of insulated live wire in each crossing should be shorter than the distance between the two couples of trolley collectors, 10 m. (32 ft. 10 in.). In the arrangement of the conductors and section insulators of the crossing, account must evidently be taken of the width of the collectors—these latter have always to be guided—and of the fact that a short-circuit between the two aerial phases may occur through the two collectors of the same phase connected together. When it is remembered that the aerial switches and crossings of the electrified Italian railway system have not always the selfsame features, the difficulties of arriving at one single type of trolley are easily conceived.

The simple crossing, "F.S." type, is shown in Figs. 15 and 16; it is generally called the "aeroplane" type, owing to the similarity of its framing to that of a monoplane. This is the type most generally met with on the Italian lines; in the new work of electrification, however, it has been abandoned, since it is not sufficiently safe. It is very heavy; the tension of the wires is difficult to regulate and to maintain, and the sagging of the wires may cause sudden interruptions in contact at high speeds of travel. Its weight renders it liable to heavy oscillations. The framing requires a number of porcelain insulators and two or three wood section insulators.

The English crossing is notably more simple than the former, as will be seen by reference to Fig. 10 of the Lecco-Calolzio track, which also shows the crossings on longitudinal catenary suspensions. With this type the wires can be suitably stretched, and the action is sufficiently safe even at high speeds. This type is also being substituted by another in the lines in course of construction.

The Donati crossing (Fig. 2, page 80 *ante*) is used in all new lines. Its notable feature is that it does not involve a special position of the supports, as is the case with the preceding types. This is of importance, for in the stations difficulties and hindrances have frequently to be met, owing to existing underground works, signals, &c. The track with section insulators is replaced by a conductor completely insulated with "Succursale" insulators, which act as a guide for the collectors. The Donati arrangement has been fitted over the crossing of the two Giovi double-track lines, where there are 12 change-overs, which previously formed one of the weak points in the Giovi electric railway, and it is being rapidly introduced in all the other lines, a circumstance which tends to show that the problem of electric cross-overs, one of the most difficult with three-phase traction, is on the way to a satisfactory solution.

The Spinelli crossing was adopted on the Monza-Lecco line. This is much more simple than the preceding ones, and it allows of a high mechanical tension of the wires. No difficulty is experienced in regard to using it, and it requires a minimum number of insulators. It was designed for service with high-speed locomotives.

RUSSIAN TRADE.—The recent proceedings of the Sales Managers' Association, at which this subject was discussed in a practical form by leading Russian commercial authorities, and regarding which an article appeared in our issue of November 17 last (page 485), is now published in pamphlet form, and copies may be obtained by sending 3*d.* in stamps to the hon. secretary, Mr. S. F. Talbot, 60, Wilson-street, Finsbury-square, E.C.

THE HEROULT ELECTRIC FURNACES.—According to the *Iron Age*, the United States Steel Corporation has granted a licence to the Milbury Steel Foundry Company, Milbury, Mass., for a 2-ton Héroult electric steel furnace, to be used to make steel castings from cold scrap. This brings the total number of Héroult furnaces in operation or contracted for in the United States and Canada to 83. The new 20-ton Héroult electric furnace at the plant of the Carnegie Steel Company, Duquesne, Pa., was successfully started about the middle of November, and has been producing steel ever since from hot metal from the open-hearth department.

ILLUMINATION AS A FACTOR IN MANUFACTURING COSTS.—A pamphlet by Mr. A. S. Hubbard, recently issued by the Westinghouse-Cooper Hewitt Company, Limited, suggests some rather novel aspects of the illumination problem. To be efficient, illumination should be ample, but free of glare, steady, uniform (not patchy or streaky), and free of heat and ultra-violet rays. It is probably correct that the sun is the worst of all sources of illumination, both as to glare and ultra-violet rays. Mr. Hubbard is certainly right when he insists that strain of the eye by insufficient or unsuitable illumination is a very serious matter—not for the eye alone, but for health in general, and that the cost of the lamp current is not by any means the most important item for factory lighting. A kilowatt for 1 hour (at ½*d.*), he points out, is equivalent to 100 watts for 10 hours; those 100 watts would feed two 16-candle (carbon-filament) lamps, or one 80-candle metal-filament lamp, or ½-arc, or ¼-Cooper-Hewitt lamp, all of which might therefore be kept burning for 10 hours for ½*d.*; and if that illumination were in each case for the benefit of only one operator, the light would cost ½*d.* per day per man. Now an operator earning 8*s.* 4*d.* a day (to facilitate calculations) would earn ½*d.* in three minutes, and his light bill would only represent three minutes' work. Yet current-saving is, of course, desirable, and the mercury-vapour lamp compares well with the ½-watt lamp, as both require from 0.7 to 1 watt per spherical candle, against 0.8 to 1.5 watts required by the tungsten lamp and 3.6 or more by the carbon filament. Good illumination depends, of course, on a good many factors, and the question has been receiving due attention of late.

ITALIAN ELECTRIC RAILWAYS.

(*For Description, see Page* 101.)

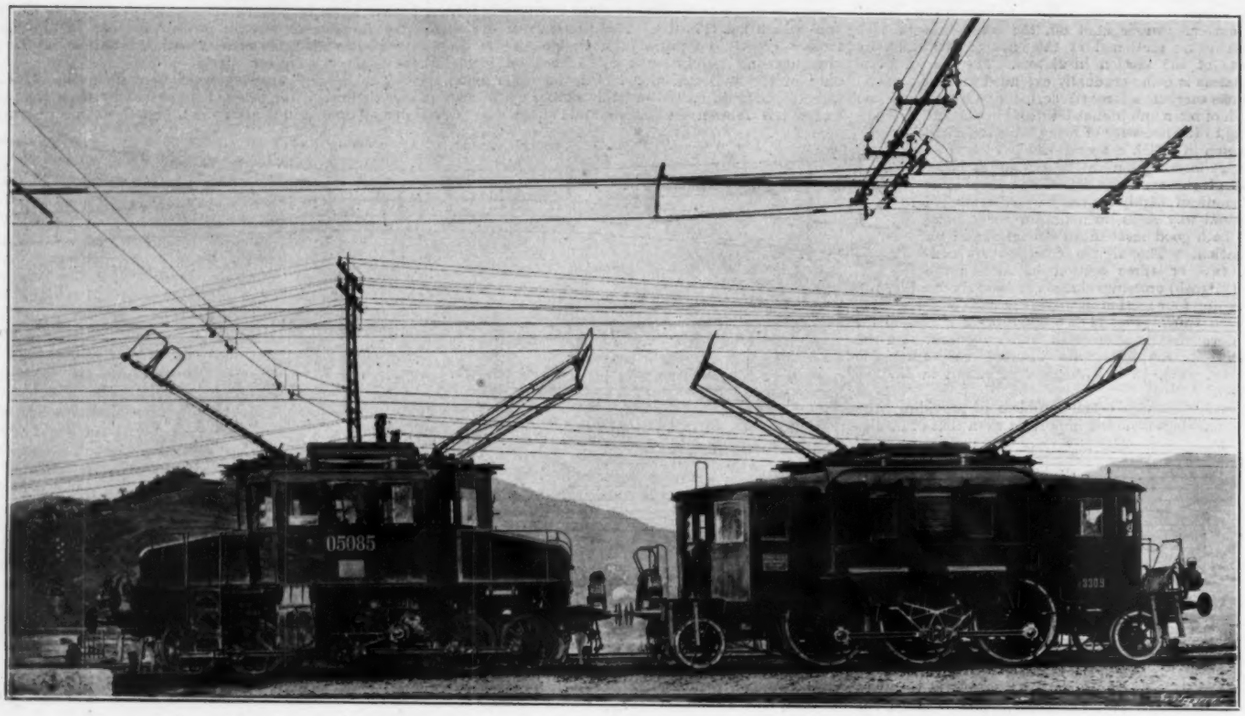
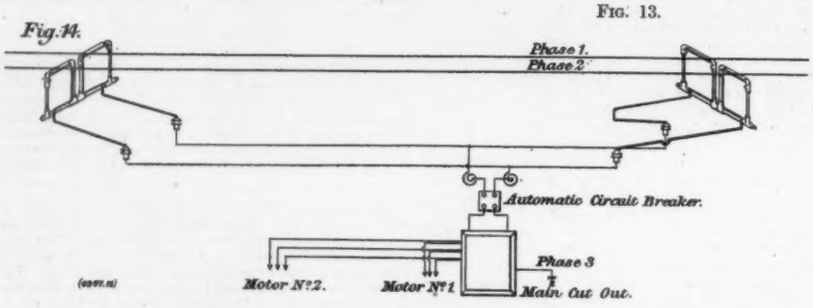


Fig. 13.



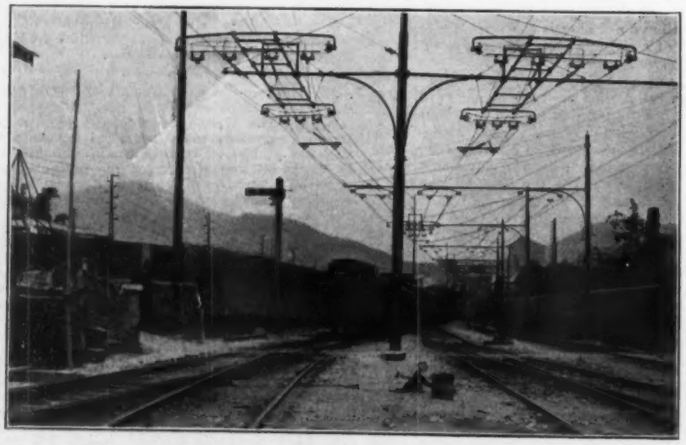


Fig. 16.

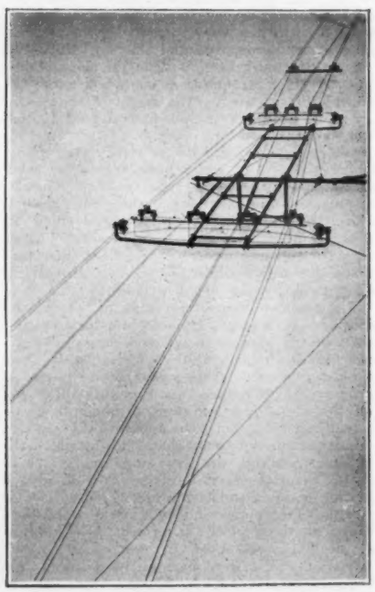


Fig. 15.

Metal Sheet Testing. — For many operations to which sheet metal is submitted, tenacity and ductility are of more importance than Brinell hardness, ultimate strength and elongation observed under tensile stress. Mr. A. M. Erichsen, a Norwegian engineer, we see from *Metallurgical and Chemical Engineering* of December, 1916, has constructed a simple machine for testing sheet metal to be used in stamping presses, &c. The machine can deal with sheets of metals and alloys from 0.1 to 5 mm. in thickness; slightly modified and provided with special attachments the machine can also test wires up to 6 mm. in diameter, tubes, cartridge cups, flat springs, &c. The specimen is clamped between a die and a holder. Within the latter moves a tool with rounded end, actuated by a ram, which advances when the hand wheel of a micrometer screw is turned. The first measurement is taken at contact between tool and sheet; this measurement gives the thickness of the specimen, the drum having previously been set to zero. A zero adjustment having once more been established, the tool is further advanced; the sheet then bulges out like a helmet, until a crack develops. When the machine and specimens are made to Erichsen's specifications, the results are comparable.

RIVETING MACHINE FOR SHELL BASES.

CONSTRUCTED BY MR. T. WICKENS, ENGINEER, MAIDSTONE.

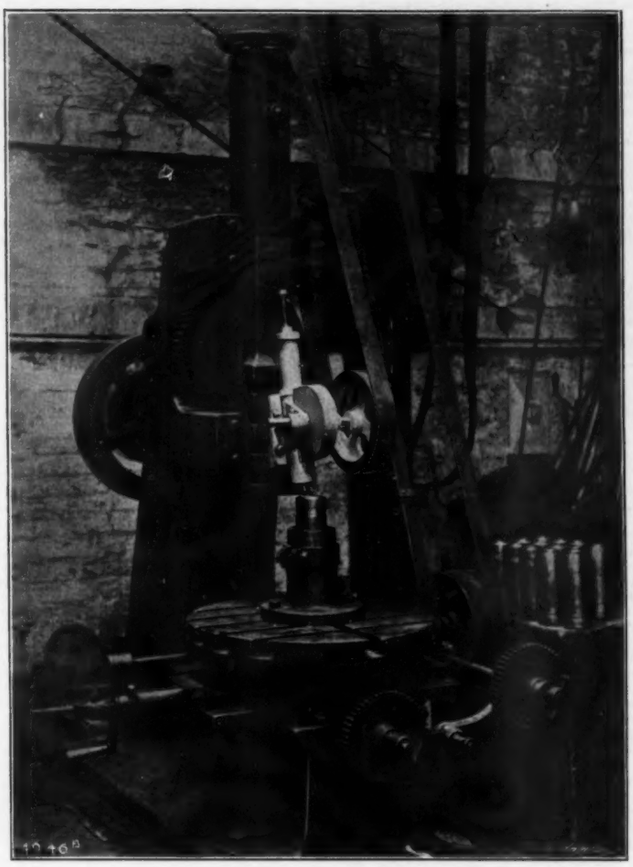


FIG. 1.

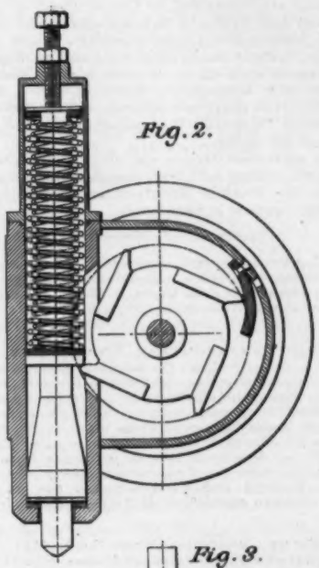


Fig. 2.

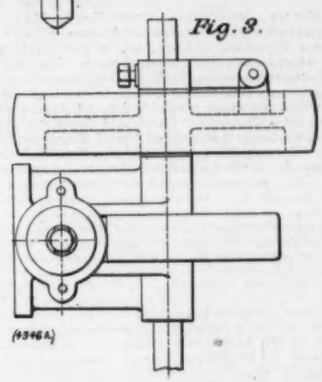


Fig. 3.

WE illustrate above a very neat little machine for riveting in the base plates of shells and shell adapters which has been devised and constructed by Mr. T. Wickens, of 33, Salisbury Road, Maidstone. The first machine of this kind was constructed by Mr. Wickens for his own use more than a year ago, and it proved so convenient and effective that a large number of the machines have since been made and are in use in various establishments engaged on munition work.

The great feature of the device is that it can be used as an attachment to an ordinary slotting machine or lathe, the perspective view, Fig. 1, showing it as used in connection with a slotting machine. Referring to Figs. 2 and 3, it will be seen that the device consists of an accurately bored cylinder, in which works a sliding plunger having an interchangeable striker attached to its lower end. The upper part of the plunger is encircled by a helical spring which bears against a collar on the plunger, and the pressure of which is adjustable by the screw shown. Mounted on the side of the cylinder, and at right angles to it, is a flywheel shaft carrying a cam wheel (shown in Fig. 2) provided with four removable tappets. During the rotation of this cam-wheel these tappets project through a port formed in the side of the cylinder and act on the collar of the plunger, raising it against the pressure of this spring and suddenly releasing it. A flywheel is mounted on the cam shaft, but is not rigidly fixed to it. A fixed arm is mounted on the cam shaft outside the flywheel, and is connected to the latter by a special flexible coupling. This arrangement relieves the cam points from shock, especially doing so when the hammer strikes solid metal, causing a rebound.

The arrangement gives a smart blow very suitable for riveting, and of course four blows are given for each revolution of the cam-wheel shaft. The force of the blow can be regulated from a slight tap to a very heavy blow, and the force, when once adjusted, is not affected by a change in the speed at which the machine is run, but remains constant. At first some difficulty was experienced in getting the springs to stand as long as was desirable, but this difficulty has been overcome, and the spring which Mr. Wickens is now using is of a type which has been tested up to 15,000,000 blows.

The machine is at present being made in two sizes, one fitted with a hammer suitable for adapters and shells up to 4.5-in diameter, and the other suitable for larger shells. Although designed specially for riveting shell base plates, some of the machines are now being used for several other purposes, such as for closing ordinary rivets and for planishing. The hammer can of course be worked either vertically or horizontally, or at any angle. One of the smaller machines attached to a slotter, as shown in Fig. 1, rivets up the base of an 18-pounder shell complete in 1¼ minutes, 540 blows being delivered per minute, and the shell being revolved three times during the operation. When employed on No. 10 shell adapters, the device will rivet up 300 adapters per hour.

THE FRANKLIN AIR-COOLED MOTOR ENGINE.

WE illustrate this week on page 106 and on Plate XI a type of air-cooled motor engine constructed by the H. H. Franklin Manufacturing Company, of Syracuse, New York, U.S.A., which embodies some interesting features. The air-cooled type of motor engine—except in the case of quite small powers—is one which hitherto has not received the full attention it deserves. Its advocates claim that its adoption in place of water-jacketing, with its attendant radiator, saves weight and cost, while in cold climates it does away with troubles consequent upon the freezing of the cooling water. The H. H. Franklin Manufacturing Company have paid particular attention to this type of engine for many years past, and the example of their most recent practice which we now illustrate has therefore a special interest.

A very good idea of the appearance of the engine is given by Figs. 1 and 2 on page 106, which show respectively the left and right hand sides of the engine. The flywheel, which is also a fan, has its blades all cast on it, and is also shown in these figures. The engine illustrated has six cylinders of 3¼-in. bore by 4-in. stroke, giving a maximum of 31 h.p. at 1,700 revolutions per minute.

The engine in part section is illustrated in Fig. 3, on Plate XI, which shows the vertical steel cooling fins cast integral with the cylinders, and also shows the fins surrounded by a jacket of aluminium (seen also in Figs. 1 and 2) to ensure the passage of air along the whole length of the cylinder. The space under the bonnet is divided into two parts—an upper and lower—by means of a division plate as illustrated in Figs. 1 and 2, so that the air which enters at the front of the bonnet is drawn round the cylinders and is expelled through the fan. By this means the cool air passes over the hottest part of the cylinders first.

The valve gear is of the overhead type and is totally enclosed, while the rockers are kept clear of the cylinder heads, so that the cooling of the cylinders is not interfered with. The details are shown very clearly in Figs. 3, 4 and 5, on Plate XI, which also show the lubrication system, a recirculating force feed pump being employed which forces the oil through the hollow crankshaft to the bearings and cylinder walls.

The pistons are made of aluminium and are well grooved, so as to have a close enough fit without fear of abrasion. Each piston has a shallow square groove of screw-thread form turned in it, this groove extending from the bottom of the skirt to just below the lowest ring. This groove retains oil and allows the pistons to be made a closer fit than would otherwise be satisfactory. The fact that aluminium pistons can be employed proves that the air-cooling system is a success. The carburettor used on this engine is of the Franklin standard design and manufacture, and is provided with an exhaust heater for very cold

weather. It is fitted in a very high position, and in consequence is very accessible.

On the right-hand side of the engine will be noticed a motor generator and on an extension of its shaft a tyre pump. The motor generator is used for starting the engine and lighting the car, and is driven by means of a silent chain. The silent drive and the 2 : 1 camshaft gear are illustrated in Fig. 6, Plate XI. The ignition system employed on this engine is that known as the Atwater-Kent battery system, which automatically controls the ignition point and so dispenses with a spark lever on the steering wheel. The large end and main bearings are shown in Fig. 7, which shows the crank case lower half removed for inspection purposes and illustrates the accessibility of the inner portion of the engine.

These air-cooled engines are not experimental by any means, as they have been manufactured for many years by the Franklin Manufacturing Company, and have been a success in every way.

The Engineers' Club, Manchester.—In consequence of Mr. Edmund L. Hill's resignation of the honorary secretaryship of this club, Mr. H. S. Wilkinson has been appointed to undertake the duties in his stead.

Proposed Swedish-Russian Steam Ferry Connection.—The Swedish Commercial Committee in Petrograd has applied to the Swedish Commercial Department urging the establishment, as soon as possible, and preferably immediately after the close of the war, of a goods steam ferry connection between Stockholm and some Russian port, Reval or Baltic port, which later on could be developed into a passenger line. The probable establishment of regular steam ferry connection between England and Sweden makes the proposed Swedish–Russian connection all the more desirable.

The British Dominions Year Book, 1917.—This year book is edited by Mr. Edward Salmon, F.R.C.I., and Mr. James Worsfold, F.C.I.S., and is published by the British Dominions General Insurance Co., Limited, Royal Exchange-avenue, E.C. It contains close upon 400 pages, and has a number of interesting articles, among which we may quote "The Aftermath of the War," by Lord Cromer; "The War's Three Phases," by Mr. E. C. Vivian; "A Year of Naval War," by Mr. A. Follen; "Labour, Commerce, and the Empire," by Mr. E. Salmon, &c. Other articles deal with the agricultural outlook; the civil engineer and the future; war finance and the future, &c. Besides these articles, the book gives a large amount of information of general interest in the present war time, several maps showing the changes which Europe has undergone at various epochs, a number of coloured plates, and illustrated descriptions of devices of the war.

Lockwood's Price Book, 1917.—This price book is edited for the use of builders, architects, contractors and engineers by Mr. R. Stephen Ayling, and is published at the price of 4*s.* by Messrs Crosby Lockwood and Son, of Stationers' Hall Court, Ludgate-hill, E.C. It gives detailed prices for material and labour of every variety required in construction work. Owing to the present uncertain state of both the material and the labour markets, the editor suggests that the prices quoted should be increased to bring them into line with the conditions now ruling. He also urges that all quotations for specialties appearing in the book should be confirmed by inquiry of the merchants concerned, since quotations, whenever they are given, do not hold good for more than a few days Notwithstanding this case of *force majeure*, the book, like the former editions, will prove of great utility to all who are interested in the numerous branches of the building trade.

The British Electrical and Allied Manufacturers' Association.—The report of the Council of this Association for the year 1916 states that they have issued in handy form a set of "British Export Standardisation Rules for Electrical Machinery and Transformers (excluding Traction Motors)." The text of these has been settled as far as possible in accordance with present international standards and after agreement with the sections of the Association mainly interested. It is believed that these rules will, if energetically circulated, tend to displace those issued by other countries for use abroad. Translations into French, Spanish, Italian, Russian, and Portuguese will shortly be available. Members can obtain from the secretary, at a nominal charge, editions in English or any of these languages bearing their own imprint, for circulation to their foreign agents and customers. It is stated further that the Association's General Committee for Research, created at the invitation of the Privy Council Advisory Committee, has established working sub-committees to deal with the improvement of insulating materials, the corrosion of condenser tubes, special waterproof insulation for machines, magnet steel, problems of switching and arcing, turbine blading; and certain applications for grants-in-aid of research have already been lodged, while others are in preparation. Meanwhile the preliminary investigations, aimed at ascertaining the most urgent subject-matters for further work, are being conducted. It was hoped that certain researches could have been conducted jointly with the Institution of Electrical Engineers, but this has not so far been found practicable.

NOTES FROM THE UNITED STATES.

Philadelphia, January 17.

The American pig-iron market is just now in an inactive condition. There are many inquiries from European sources and from South America for a very large quantity of iron in the aggregate. The insurance and freight charges run very high and exceed the cost of the iron at the furnaces. Furnace interests are afraid to enter into large contracts for European delivery lest freight embargo by American roads will make delivery difficult or impossible. The oversold condition of furnaces makes it a matter of indifference whether European or domestic buyers come in or stay out of the market. Outside of pig-iron the greatest activity this week is in steel plates and in railroad equipments. The pressure for plates is apparently beyond all possible production for some months. Plates can be had at premium prices only, which range around 5 cents. The greatest activity in equipment lines is for cars for export. The total inquiries before the market for export alone are said to amount to 60,000 cars. It would be interesting to know what the car builders propose to do with expected business in view of the fact that they have but limited capacity unsold which will allow delivery of cars this year. European necessities are apparently on the increase. American steelmakers are straining every point to accommodate European demands. The month's car orders aggregated over 32,000 cars and locomotive orders for the month were close to 800. New capacity is steadily coming to the rescue of the market, and this expansion will probably take care of maximum necessities abroad and at home within the next half-year. There are some who believe that the crest of prices has been reached, but while this may possibly be true on contracts for delivery at the convenience of the mills, it does not apply to urgent and immediate necessities. Those who must have steel for what is considered early delivery are willing to pay whatever price is necessary to get what they want. Domestic railroads are crowding in inquiries as fast as they can be entertained.

The Schuckert Electrical Concern.—It is stated that the company has disposed of its shares in foreign undertakings in Italy and in the Norwegian Hafslund Company, and that there are many means of utilising the capital which has thus been made available. The new year has commenced with a substantial amount of orders, and prospects are satisfactory.

New Electric Iron-Smelting Process.—A new Swedish invention for electric extraction of iron, with coke as a reduction medium, is attracting much attention, although the experimental stage is not yet quite over. Important practical results are, however, confidently reckoned upon, and the new process is expected to prove advantageous, especially for Nroway, where it is being tried.

The German Lignite Industry.—The German lignite industry has fared well during the war, and better than ever in 1916. It has gained considerable importance notwithstanding the development in the coal-mining industry, and although it comprises some 300 private installations, these are controlled by comparatively few companies, some of which are fairly large concerns with a substantial capital. The shortage in the production of coal since the war broke out, some 28 per cent. for the first year of the war (as far as the Rhenish-Westphalian Coal Syndicate was concerned), compared with the preceding 12 months, and about 10 per cent. for the second war-year, caused an immense increase in the demand for lignite, and, as the following figures show, the production, in spite of shortage of labour, was larger in 1915 than in 1913:—1913, raw lignite production, 87,100,000 tons; briquette production, 21,400,000 tons. 1914, raw lignite production, 84,000,000 tons; briquette production, 21,400,000 tons. 1915, raw lignite production, 88,400,000 tons; briquette production, 23,300,000 tons. The year 1916, for which no final figures are available, is expected to show a further rise. From a financial point of view, also, the results of the lignite industry during the war have proved quite satisfactory in spite of materially increased expenditure. This appears from the results obtained by the 20 or so leading lignite concerns, having an aggregate share capital of 231,850,000 marks, which represents about two-thirds of the total capital invested in the German lignite industry. The aggregate profits of the 20 concerns referred to show but a slight decline in 1914–15 as compared with 1913–14, and in the next financial year (1915–16), with increased writings-off, &c., the result even surpassed that for 1913–14. The average dividend for 1913–14 was 10.4 per cent., the following year a decline of 0.7 per cent. set in, but a rise of 1.1 per cent. for 1915–16 again raised the figure to 10.8 per cent. The current financial year is likely to witness a continuance of this upward movement, as lignite prices have recently been raised in all lignite districts. The war not only has not done this industry any harm, but it has opened out new markets and has brought new classes of consumers. Lignite has now also become a factor of some moment in various chemical industries. As a direct consequence lignite deposits are eagerly sought after, and a number of sales to some of the largest industrial concerns in Germany have been recently effected. The prices of lignite shares have risen very materially; thus the German Petroleum Company, which is going in for tar production from lignite on a large scale, recently paid 185 per cent. for shares in the Rositz Lignite Company, which shares were below par before the war. In addition, combines and new companies have been formed, and increases of capital have taken place during the war.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—In the Scotch steel trade, particularly in the West of Scotland, there is unmistakable evidence that the ever-growing strength will increase and continue for some considerable time to come, many of the local works being well booked up with orders months ahead. Even with this, and with every mill running to its fullest capacity, the supply continues to lag far behind, nor is it possible for makers to avoid this unsatisfactory condition of affairs, which in one way is brought about by the difficulty of procuring sufficient supplies of raw material. The demand for steel in considerable quantity for the new vessels ordered by the Ship Controller to be built on the Clyde has placed an additional burden on the shoulders of the makers. Notwithstanding the increased pressure the will of masters and men is firm, and without doubt every obstacle will be successfully surmounted, and everything possible be done to speed up the construction of the vessels to be dealt with under this new Government scheme. Export trade generally is daily becoming of less and less moment. Prices keep firm and much on the level of last week.

Malleable Iron Trade.—With the bulk of the output of malleable iron reserved for Government purposes, it is not surprising that little or nothing is available for the use of general consumers, or that makers have found it impossible to guarantee delivery of any orders other than those required for the various Government Departments. Where orders for general mercantile work have been booked it is on the express understanding that they can only be put through after the war contracts are completed. All the plant is fully employed, and every establishment as busy as the shortage of skilled labour will permit. "Crown" bars are still quoted round about 14*l.* 12*s.* 6*d.* per ton for export, the rate for some of the better brands being considerably in excess of this.

Scotch Pig-Iron Trade.—Nothing could exceed the activity in the production of the supplies of pig-iron of every grade required directly or indirectly in the making of war material. In order to push forward the manufacture of steel, a very determined endeavour is being made to increase the output of hematite, the demand for which is exceptionally strong. A very decided feeling prevails that, to provide the necessary amount of steel for munitions and similar purposes, the supply of raw material must be so well maintained that no deficiency can possibly occur. Consequently, every furnace is in full blast. The iron works are making considerable demands for forge and foundry qualities, although there is still an appreciable scarcity of No. 1 grade. When war requirements are satisfied, practically nothing is left over for export.

Dutch Industrial Fair.—The General Consulate for Holland in London informs British merchants that from February 26 to March 10 next a fair for the purpose of promoting the trade and the industries of the Netherlands, the first of a series of annual fairs, will be held at Utrecht. Intending visitors should correspond for all information with the Algemeen Secretariaat, Jaarbeurs, Utrecht, Holland.

Prohibited Exports.—A supplement to the *Board of Trade Journal* of January 25 contains complete lists of articles which, according to the latest information received by the Board of Trade, are prohibited to be exported to various destinations from the Straits Settlements, Hong Kong, Nigeria, Gold Coast, Jamaica, Barbados, Trinidad and Tobago, and British Guiana. The supplement may be obtained at the price of 3*d.* per copy (post free 4*d.*) through any bookseller, or directly from His Majesty's Stationery Office, Imperial House, Kingsway, London, W.C.

Prussian State Railways.—The Prussian Minister of Finance, Dr. Lentze, on introducing the Ways and Means Bill, stated that the revenue of the State railways were materially influenced by the war; the receipts from passenger traffic decreased more and more, whilst those from goods traffic increased. Some military accounts for 1915 had to be carried forward to 1916, so 1915 showed a shortage of 96,000,000 marks, which properly should be covered by the equalising fund, but as this only showed a balance of 6,200,000 marks the difference, 89,800,000 marks, had to be covered by a deficit loan, but it should be observed that interest and sinking fund on the capital invested had been provided prior to the above deficit. For 1914 the deficit was 116,000,000 marks.

Prussian State Mining.—The programme for the current year shows a calculated net surplus of 22,347,429 marks, against 20,849,364 marks for 1916. The working receipts of the various State mines and connected concerns are put at 409,881,710 marks, against 357,506,410 marks for the preceding year. The increase is principally on the production of coal, coke and by-products, viz., 46,321,290 marks, but ores also show an increase from 12,400,000 marks to 15,300,000 marks, as do the silver and lead works, &c., whilst some minor concerns figure at smaller totals. Among other revenues may be mentioned those from the Brunswiek and Schaumburg-Lippe concerns, with 11,900,000 marks. The expenditure shows a corresponding rise to that of the receipts; thus wages have risen from 164,100,000 marks in the preceding year to 190,900,000 marks, in spite of a smaller number of hands being employed, and raw materials, tools, &c., from 81,600,000 marks to 96,500,000 marks.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Pressure is being maintained upon the collieries for full and prompt deliveries, but through various causes, including the vexed problem of wagons and the considerable percentage of absenteeism, the output does not satisfy all requirements. The colliery "comb" is also having an unsettling influence, but this is regarded as merely a temporary interference. Inland industrial users demand very large tonnage of all classes of steam fuel on contract account, thus leaving the open market practically bare of supplies. Export trade shows increased activity, and prices are about 8*s.* per ton higher than the home sales. The severe weather has led to a brisker inquiry for household sorts, but though depots possess good stocks, difficulties of carting make the work of distribution a trying one. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.*, per ton at the pit.

Iron and Steel.—The demand for all grades of raw and semi-finished material continues to be exceedingly strong, and few contracts can now be placed at other than the top figures. Swedish material is perhaps the most difficult to get, but prominent manufacturers inform us that they are not anxious upon the subject, for they have ample supplies for their present needs, particularly in the case of bar iron, and a little to spare for the distant future. Of course a tightening up of the market has followed upon the reduction of the tonnage imported, and seriously inflated prices have to be paid for anything bought in the open market to-day. Swedish pig is changing hands in Sheffield at 30*l.* per ton, bar iron 40*l.* per ton, and steel billets up to as much as 45*l.* per ton. Makers of common irons are not able to satisfy all requirements, though they are managing to dispose of a good tonnage of foundry quality at 92*s.* 6*d.* delivered. A well-known local firm has just received sufficient orders from the Government to employ its four large furnaces upon the production of special qualities of motor-car steel. Skate makers are now merged into the motley collection of allied engineering industries engaged upon munitions, and they are producing vast quantities of tools. The makers of high-speed and carbon steel are still engaged at high pressure, and are assisted by full supplies of tungsten from the Sheffield owned mines in Burma and Australia. The next few weeks will witness important developments in the laying down of additional plant to produce special sizes of drills for shipbuilding work on the Tyne and the Clyde. Women are being trained for much of the repetition work on the machines, and they will be introduced into the new shops under the supervision of qualified fitters and millers. Large orders are being received by agricultural engineers for reaper and mower sections, hay-making implements, cultivators, barrows, plough plates, steel tractor castings, &c., but only a portion of these can be accepted. A great obstacle is the difficulty in obtaining full deliveries of steel. The general export trade is engaging full attention. Indents have arrived for all manner of machinery and parts, scythes, knives, files, saws, hammers, plane irons, machetes, steel, cutlery, and electro-plate.

X-Rays in Metallurgy.—The Sheffield Society of Engineers and Metallurgists, on Monday, January 29, discussed the application of X-rays in metallurgical research. Professor J. O. Arnold, of the Sheffield Applied Science Department, pointed out that steel crystallisation was a matter about which too little was known. They could not afford to neglect any knowledge, physical or chemical, which they could gather on the subject. Professor Bragg, of the Leeds University, stated that chemistry told the metallurgist what were the constituents of his metals, but the application of X-rays was going to help him to find exactly how the atoms of the substances were arranged and the distances which lay between the crystals in the metals which he handled. After all, this question of arrangement was important. Further progress would be made after the war, and there would be the prospect of getting useful information about iron and steel. Americans, uninterrupted by the war, were forging ahead in the matter.

Professor J. O. Arnold.—The Sheffield Society of Engineers and Metallurgists has unanimously re-elected Professor J. O. Arnold, of the Sheffield University, as its president.

Sheffield Munitions of War Committee.—Alderman A. J. Hobson was this week elected chairman of this committee in succession to his old friend and business colleague, the late Col. Herbert Hughes.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a fair amount of activity in Cleveland pig-iron. Allocations for February are being made pretty freely and quite a number of contracts are being arranged. Demand for Scotland is rather heavy, and there are substantial inquiries on behalf of our Allies, whilst there are also occasional efforts to purchase for neutral countries. Home consumers are well placed for the time being, and are not keen purchasers for early delivery, but they are putting out considerable inquiries on forward account, and makers now show more disposition to favour such business, as it obviates making numerous small contracts. Licences for export, though still rather difficult to secure, are being more freely issued wherever tonnage is available. For home consumption No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge all stand at 87*s.* 6*d.*; and No. 1 is 91*s.* 6*d.*; whilst for shipment to our Allies No. 3 is 97*s.* 6*d.* to 98*s.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*, and No. 1, 102*s.* 6*d.*; and for export to neutral countries No. 3 is 105*s.* and upward, and No. 1 not less than 110*s.*

Hematite Iron.—So far as East Coast hematite iron is concerned, allocations are very strictly controlled, but home consumers experience no difficulty in obtaining ample supplies for all legitimate needs, and fairly large parcels are available for despatch to our Allies, to whom some rather heavy shipments have been made recently. Export licences for moderate amounts of new business have been granted, but such permits are still issued rather sparingly, as there remain certain arrears of export on old contracts to be fulfilled. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Output of Pig-Iron.—There is reason to believe that production of pig-iron will be increased in the near future, but for the time being output is slightly reduced. At one works two furnaces have been temporarily taken off hematite, and an additional furnace has been put on to Cleveland pig. This makes the number of furnaces in operation on the North-East Coast 75. Of these 31 are turning out Cleveland pig, 32 are producing hematite, and 12 are manufacturing special kinds of iron.

Stocks and Shipments of Pig-Iron.—Makers' stocks of pig-iron are very small, and the quantity of Cleveland sorts held in the public warrant stores here stands at only 2,748 tons, composed of 2,712 tons of No. 3 quality, and 36 tons of other descriptions of iron deliverable as standard. Since the beginning of January the stock has been reduced by the withdrawal of 990 tons of No. 3. Shipments of pig-iron from the port of Middlesbrough for the first month of the year are estimated at 40,000 tons, as compared with 35,909 tons for the previous month, and 48,183 tons for January last year.

Coke.—Firmness continues to characterise the coke trade. Local consumption keeps heavy, and no difficulty is experienced in realising the fixed maximum quotations that have ruled for some months past. Thus average blast-furnace qualities are 28*s.* at the ovens, and low phosphorus sorts 30*s.* 6*d.* at the ovens.

Foreign Ore.—Imports of foreign ore to the Tees during the first month of the year approach 200,000 tons.

Manufactured Iron and Steel.—Little news is ascertainable concerning the various branches of the finished iron and steel industries. Manufacturers keep very fully employed, and they report a continued steady growth of production of mercantile shipbuilding material, the output of which has now assumed very considerable proportions. Values of all descriptions are well upheld. To home customers the following are among the principal market quotations:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 12*l.*; packing iron and steel (tapered), 14*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—New business has been virtually at a standstill on account of a scarcity of tonnage. There has been practically no demand for coals of any class. In the circumstances prices are purely nominal and dependent on the individual circumstances of buyer and seller. Collieries are also finding it a difficult matter to keep their pits going, and to obtain a release of wagons have been ready to grant very material concessions to buyers able to take prompt or spot delivery. The frosty weather has also interfered with the rapid loading of ships. At all the local ports trouble has been experienced with the hydraulic plant, and at Newport on one day all the tips were stopped for about five hours owing to one of the hydraulic pipes bursting. The chief difficulty, however, has been to get the coal out of the trucks, it having got frozen in and having to be dug out. These difficulties have, however, had an insignificant effect, as the available tonnage is so small that it has been possible to move vessels from tips temporarily stopped to those in working order. For prompt and spot loading second Admiralty large coals were obtainable round 26*s.*, Western Valley and Black Veins from 25*s.*, and good Eastern Valleys from 24*s.* Small steams were also in very poor demand, with best bunker descriptions securable from 17*s.*, seconds from 16*s.*, and cargo sorts from 10*s.* to 15*s.*, according to quality. The export demand for bituminous coals has also been very slow, and prices were nominally round 27*s.* for No. 3 Rhondda large, 20*s.* No. 3 smalls, 24*s.* No. 2 Rhondda large, 19*s.* No. 2 through, and 16*s.* for No. 2 small. Though there is not much patent fuel available for shipment, the lack of ready tonnage has caused makers to reduce their prices to 33*s.* Coke for export was scarce, with prices round 63*s.* for special foundry, 60*s.* ordinary foundry, and 50*s.* furnace. Pitwood has been practically unobtainable, and for the small parcels changing hands 60*s.* has been readily paid.

Western Trade Matters.—At last the authorities have made a move for the purpose of attracting neutral vessels to Allied trades. On Monday it was officially announced that in order to meet the increased cost of war insurance limitation rates to the French Atlantic and Bay ports for neutral vessels had been raised by 20 per cent., and for the French and Italian Mediterranean schedule ports by 50 per cent. Time charter rates have also been increased to a maximum of 47*s.* 6*d.* for vessels over 1,000 tons and to not exceeding 52*s.* 6*d.* for boats under 1,000 tons. Single voyage rates for neutral vessels from the Bristol Channel will now be: Rouen, 29*s.* 5*d.*; Bordeaux, 40*s.* 9½*d.*; Havre, 27*s.*; Honfleur, 27*s.* 7*d.*; St. Malo or St. Servan, 25*s.* 2*d.*; St. Nazaire and adjoining ports, 34*s.* 9½*d.*; Algiers, 72*s.* 9*d.*; Genoa, 89*s.* 3*d.*; Marseilles, 87*s.* 9*d.*; and Naples, 86*s.* 3*d.* The general local opinion is that the rise has come too late, and that it will not voluntarily attract and retain neutral vessels in the Anglo-French and Anglo-Italian trades. One effect of the advance in rates has been to cause a very appreciable spurt in rates for non-scheduled ports. For instance, Barcelona has paid 90*s.*, against 80*s.* in the previous week; Lisbon 70*s.*, against 53*s.* six days previously; and Carthagena 88*s.*, compared with 65*s.* three weeks before.

Payment for Pitwood.—The Cardiff and Bristol Channel Importers' Association has decided that sales effected from February 1, 1917, shall be for net cash at 14 days instead of 30 days as at present. The Monmouthshire and South Wales Coalowners' Association has recently had under consideration the question of the supply of home-grown pit timber. A committee had been appointed to find the best way for dealing with the matter, and have come to the decision to form an association of colliery owners to arrange for the purchase, supply, and distribution of pitwood to members. A form of undertaking has been prepared for intending members to fill up and sign and send to the secretary not later than February 8, when a meeting of the colliery companies who intend to join the association will be held. Every year over 1,000,000 loads of pit timber is imported into South Wales, and though local firms have for some time past been tapping new sources of supply abroad and at home, difficulty is still experienced in obtaining timber in sufficient quantities.

Miners for the Army.—The decision of the Government to comb out the coal mines has come as a surprise to the trade, especially as the late Government was never tired of pointing out the importance of increasing outputs. Medical Boards are going through the coalfield examining men. The Miners' Federation and the Coalowners' Association have, however, had interviews with the Home Office on the subject. As a result of these negotiations the comb out has been temporarily suspended, and it is hoped that an arrangement will be reached whereby the colliery owners will be given an opportunity to express to the Home Office the best method of getting the required number of men and the same proportion from each colliery.

Swansea Labour Pooling Scheme.—In order to conserve and add to the efficiency of dock labour the working conditions at the Swansea docks were changed on Monday last. A clearing-house will be established, where dock labour will report and employers will also make known their requirements as far as possible. Available labour will then be allocated to the various wharves and works, and in this way it is hoped to speed up the work at the docks.

Cardiff Shipbrokers' Institute.—The Cardiff shipbrokers have decided to establish an association, to be known as the Cardiff Shipbrokers' Institute. A committee has been appointed to draft rules and regulations and a general meeting is to be held on Monday. Mr. S. W. Hansen, of Hansen Brothers, has been elected president of the Institute.

Newport Dockers' Wages.—Recently Newport dock and wharf workers applied for a 25 per cent. increase in wages. The request was considered by the employers, who could not see their way to grant the application. The matter was then referred to Sir G. R. Askwith, who has awarded the men a 15 per cent. advance, which they have decided to accept.

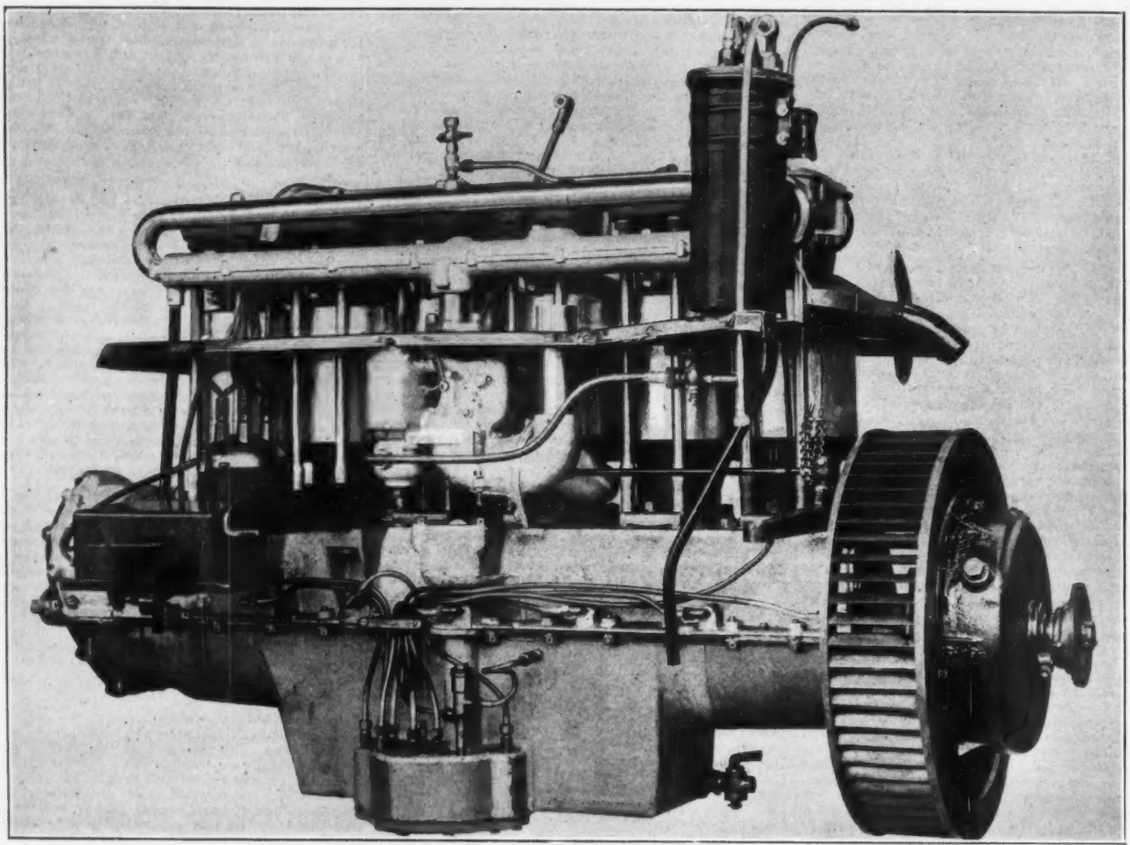
Miscellaneous.—Mr. W. J. Orders, until lately a partner in the Newport shipowning firm of Orders and Handford, died on Saturday last. Deceased, who was 54 years of age, founded the Orders and Handford Steamship Company, Limited, in conjunction with Mr. T. L. Handford, in his early days. He was an ex-chairman of the Newport Shipowners' Association and the Newport Chamber of Commerce. About 12 years ago he was appointed J.P. for the borough of Newport, and in 1915 deputy-lieutenant for the county of Monmouthshire. Recently, owing to ill-health, Mr. Orders retired from business, and Mr. Handford took into partnership the principals in John Cory and Sons, Limited.—Mr. E. P. Jones has been elected president of the Swansea Chamber of Commerce for the ensuing year and Mr. T. H. Hazell has been elected president of the Newport Chamber of Commerce.—The directors of the Taff Vale Railway will recommend at the annual meeting a dividend of 3½ per cent. on the ordinary stock for the half-year ended December 31, 1916, carrying forward a balance of 26,704*l.*

THE RAILWAY CARRIAGE AND WAGON BUILDERS' POCKET-BOOK AND DIARY.—We have received a copy of this pocket-book and Diary for 1917, which is issued at the price of 2*s.* 6*d.* by the Locomotive Publishing Co., Limited, of 3, Amen-corner, Paternoster-row, E.C. It gives over 170 pages of illustrated subject-matter on carriage and wagon construction, particulars on rolling-stock, component parts, and general mathematical data, weights and measures, &c., the second part covering the diary, arranged seven days on a page.

AIR-COOLED MOTOR ENGINE.

CONSTRUCTED BY THE H. H. FRANKLIN MANUFACTURING COMPANY, SYRACUSE, NEW YORK, U.S.A.

(*For Description, see Page* 103.)



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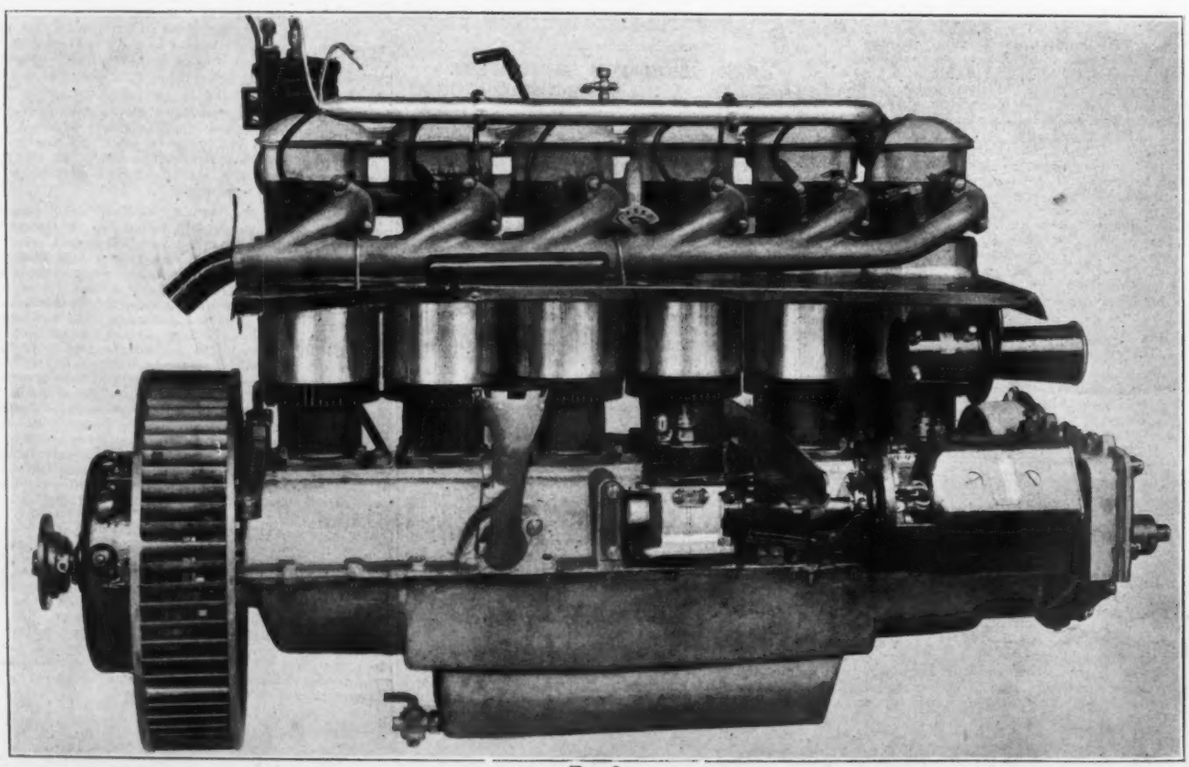

Fig. 2.

AIR-COOLED MOTO

CONSTRUCTED BY THE H. H. FRANKLIN MANUFACTURING

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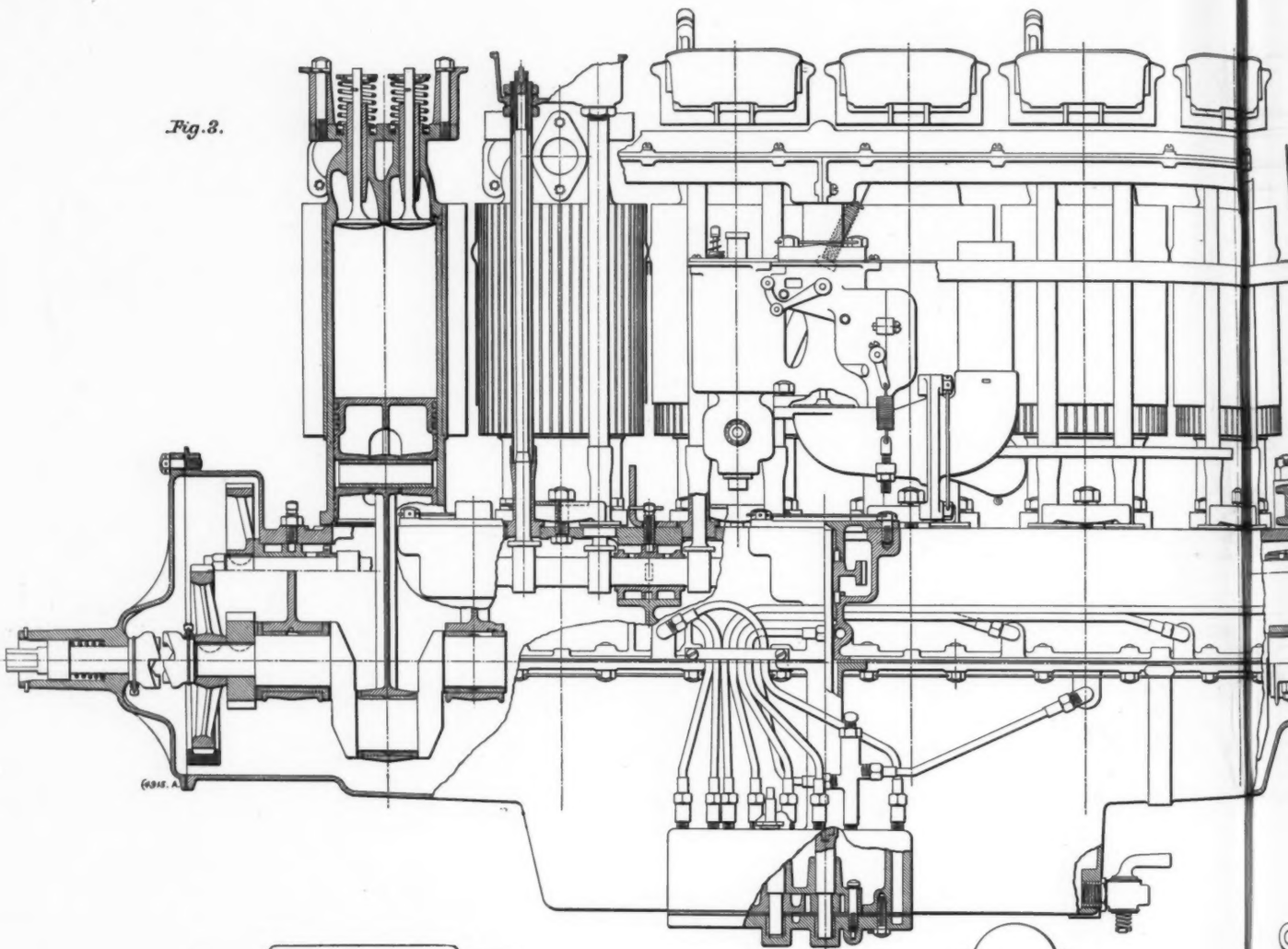

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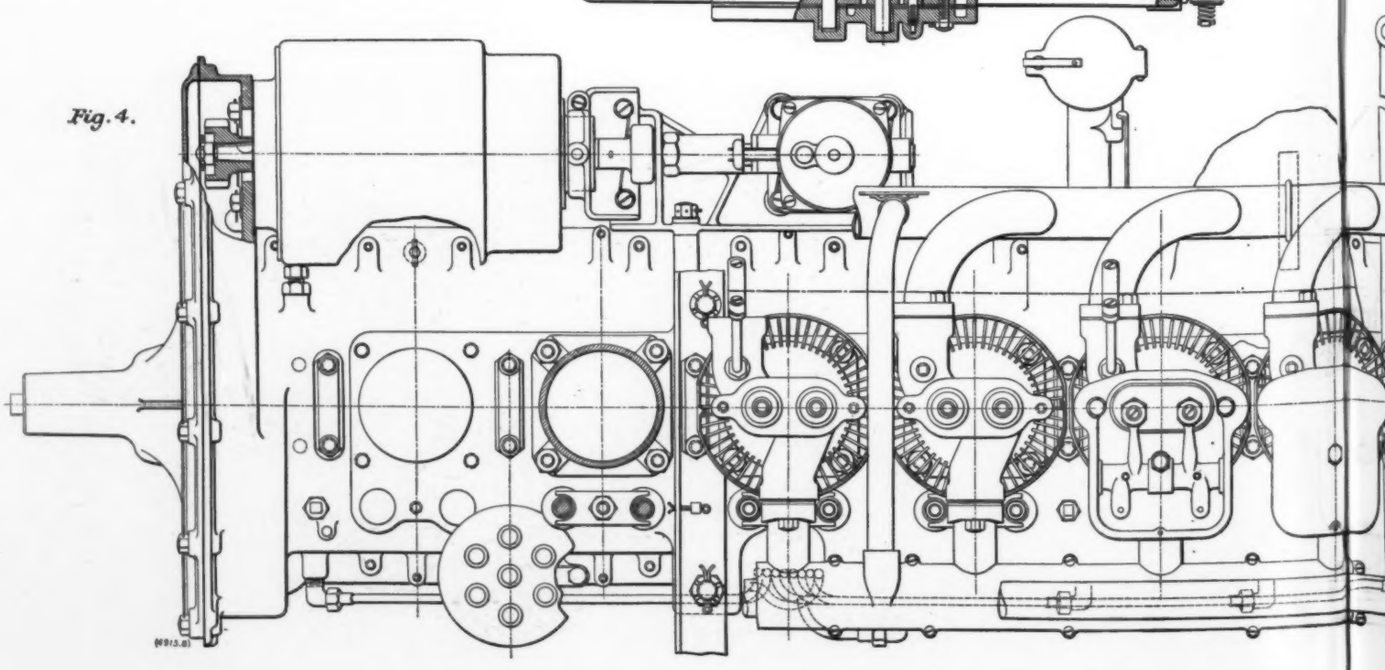

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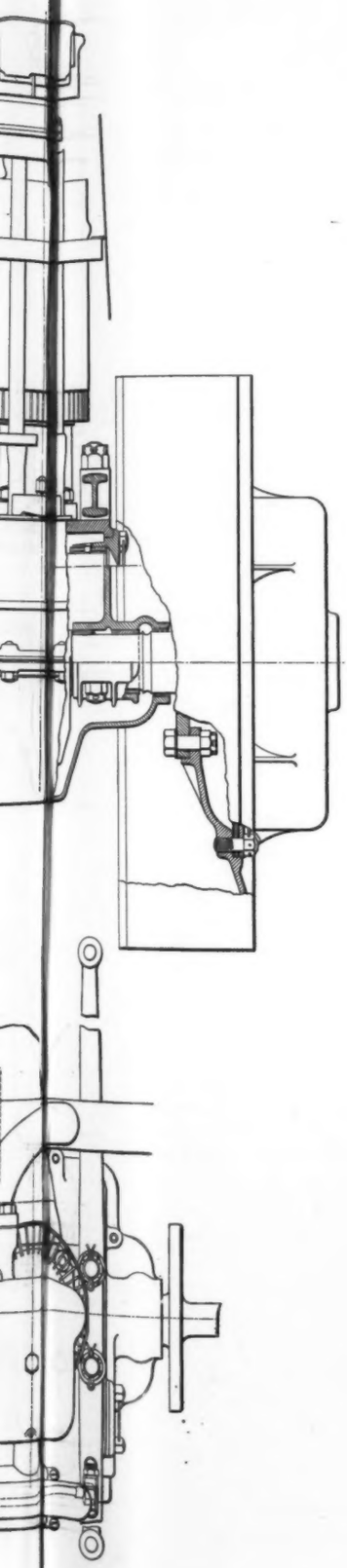

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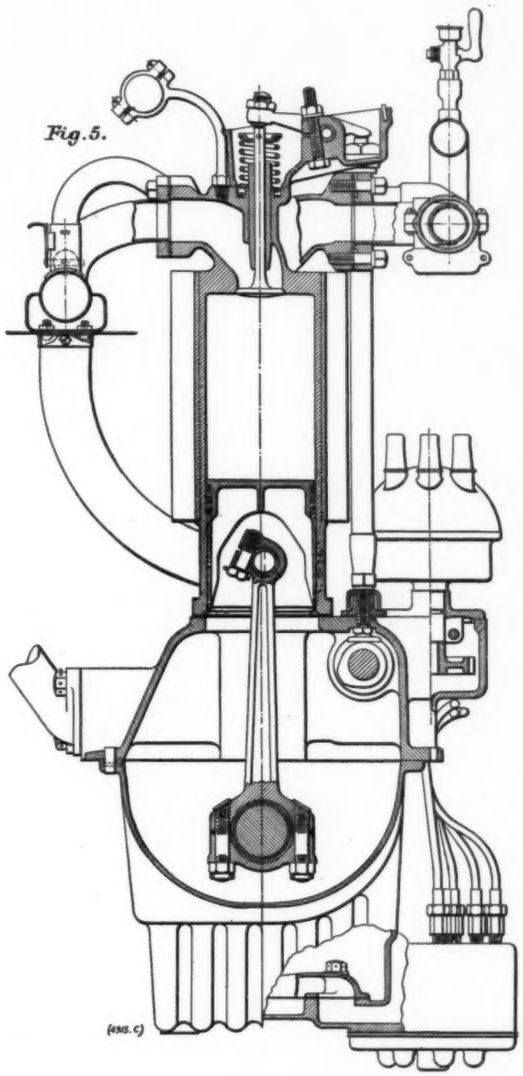

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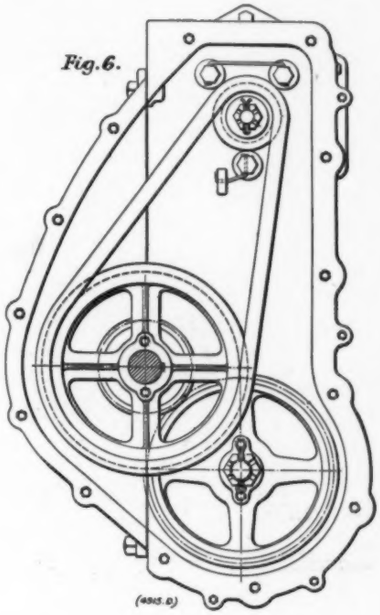

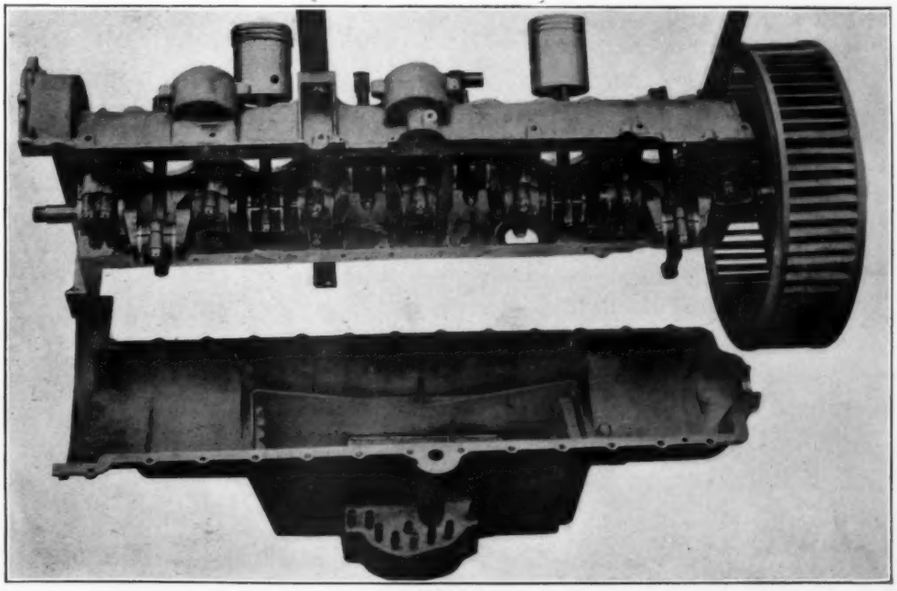

FIG. 7.

AGENTS FOR "ENGINEERING."

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ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 967-968, Monadnock Block.
For Advertisements, J. S. Allan, 608, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance :—

For the United Kingdom	£1	15	6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

For Canada—			
Thin paper copies	£1	11	6 ($7.65)
Thick ,, ...	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,, ...	£2	0	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3063 and 8598 GERRARD.

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With a Two-Page Plate of an AIR-COOLED MOTOR ENGINE.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—Monday, February 5, at 4.30 p.m. Cantor lecture.—"The History and Practice of Town Planning and Civic Architecture," by Professor A. Beresford Pite, F.R.I.B.A., Royal College of Art, South Kensington (Lecture II). Wednesday, February 7, at 4.30 p.m. "The Future of British Spas," by Mr. Robert Fortescue Fox, M.D. Sir Thomas Barlow, Bt., K.C.V.O., M.D., F.R.C.P., LL.D., F.R.S., will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 6, at 5.30 p.m. Paper to be submitted for discussion:—"The Main Drainage System of London," by Mr. George William Humphreys, M.Inst.C.E.

THE RÖNTGEN SOCIETY.—Tuesday, February 6, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. A paper will be read by Mr. R. E. Fournier d'Albe, D.Sc., "Some Properties and Applications of Selenium."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 8, at 8 p.m. "Frequency Changers," by Mr. R. Townend, Associate Member.

THE OPTICAL SOCIETY.—Thursday, February 8, at 7.30 p.m., at the Rooms of the Chemical Society, Burlington House, Piccadilly, W. Annual meeting; to be followed by an ordinary meeting, when a paper, "More Notes on Glass Grinding and Polishing," by Mr. James W. French, B.Sc., will be read and discussed.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 9, at 5.30 p.m. The evening discourse will be delivered by Mr. Daniel Jones, M.A., M.R.I. The subject is "Experimental Phonetics and its Utility to the Linguist" (illustrated). Afternoon lectures next week at 3 p.m. Tuesday, February 6. Professor Charles S. Sherrington, M.D., LL.D., D.Sc., F.R.S., Fullerian Professor of Physiology, R.I., on "The Old Brain and the New Brain, and their Meaning" (Lecture IV). Thursday, February 8. Professor F. G. Donnan, M.A., Ph.D., F.R.S., Professor of General Chemistry, London, on "The Mechanism of Chemical Change" (Lecture II). Saturday, February 10. Mr. Henry Walford Davies, Mus.Doc., LL.D., on "Colour from Diaphony to Debussy" (Lecture II).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, FEBRUARY 2, 1917.

SKILL AND PAYMENT.

JUST recently two of the most highly skilled sections of engineering effort have discussed at length the fact that their superior skill carries no adequate reward. The toolmaker and the draughtsman draw attention to the anomaly that operators of automatic and semi-automatic machines are receiving payment "beyond the dreams of avarice." That the situation is peculiar admits of no doubt, that restlessness under the circumstances is natural cannot be gainsaid. The necessity which led to depriving labour of its normal freedom of movement and choice of occupation has served to emphasize disparities existing and make troubles more acute. Skill considers itself penalised by existing conditions and rebels accordingly.

Without passing further comment upon facts galling to the toolmaker and draughtsman alike, or to other competent craftsmen or technicians, there is another side to the subject by no means generally realised. Without endeavouring to make the strings of patriotism render yet another tune—its music is differently interpreted in various hands—there is a certain consolation by contrast to be found upon looking outside mechanical effort altogether. It is necessary, to preserve our balance, to look round upon quite other occupations: where we may find analogy and parallel instances quite as acute, and though this may not solve our problem it at least helps to restore our poise and equanimity.

Premising that monetary gain is the sole end and object of all effort, and that it is the only indication of success, then the relative and accepted values of men become strangely inverted. A manure dealer with a large bank balance is a better man than a practitioner of medicine who contrives with difficulty to make a living. A rag and bone man, with his well-known opportunities of considerable profit, is superior to a research chemist, a schoolmaster, or any professional man. Education, cultivated taste, discriminating ability, and all they imply to the individual become useless by such a standard of comparison. A millionaire pork butcher is of greater moment than a poor statesman, general, admiral, or most men of great attainments and proven capacity. Both the navigating officers of a ship and the combatant officers of an army are surely underpaid if reward be commensurate with responsibility.

The fact is that there are standards of honour in occupation no less than elsewhere. The marine store dealer and the buyer of discarded clothing are both necessary occupations, and it is not desired even to discount their activity or hold them up to scorn. The point at issue is whether we are willing to pay the penalties involved in education, training and specific choice of occupation, when by reason of circumstances the rewards are relatively inferior. Poets have starved and inventors been destitute in the pursuit of their self-imposed tasks. Reward is not therefore in strict accordance with attainment. Few highly skilled men, whatever their occupation or pay, are willing to embark upon another career admittedly requiring inferior intelligence.

It is certain that when normal conditions again return the highly skilled man will not be penalised; while it is equally certain that the semi-skill of the operator now earning large wages will cause him to suffer. Actually the investment in skill or education is gilt-edged, the interest is secure: it remains the same, though never inordinate. The practice of a liberal trade will in any case secure its practitioner against want, though just as certainly it will never alone give him a fortune. Like gilt-edged stock, there are times when by comparison of price paid (capital value) with more speculative investment it seems temporarily depreciated. The interest paid remains the same, whatever the fluctuations of the market, and one reason for investment in such stock, like the investment in skill, is the security of tenure afforded. In other words there are times—the present is one—when the return for outlay may seem small by comparison, but when all is said and done it is the total results of a lifetime which need consideration. Skill of a specialist order may be entirely superseded, skill in the sense understood in the mechanical trades is never superseded. When times again become normal the discrimination against skill in the matter of payment will vanish.

That man whose occupation fits his abilities, making demands upon his entire capacity, leads a full and more or less satisfying life. His reward may be less than in some other occupations needing less ability and giving normally greater financial returns. The qualified man who exercises a liberal trade or profession, finding pleasure in his daily occupation, is universally envied by those lacking the training and education necessary, however successful otherwise they may be. The thoughtful section of the community does assess occupations at relative values; certain professions (that of the engineer among others) have some honour attached even by the general public. It is realised that liberal occupations demand intrinsically superior men, also that only a minority are endowed with ability necessary to their practice.

The argument may seem a far cry from the complaints of the toolmaker and draughtsman; but—conceding the injustice of the case made out by them—would they change? Their value and intrinsic worth in engineering economy has never been challenged or impugned. Would high wages for, say, three years compensate them for permanent reduction to capstan operators? Even temporary change-over would be against their own future interest, since the time so lost would forfeit dearly bought skill. There is a national purpose served (not by underpayment) in that the larger the number of really competent technicians, the greater the possible extension in emergency; and the nation with the greatest number of individuals of high mentality has an asset of value of tremendous significance. It is, moreover, certain that the higher posts in mechanical effort cannot be filled from the specialist or operator category. Such posts become vacant and are filled, and unless the candidate has experience of a practical order he cannot be competent whatever else his abilities. In the future, whatever has been the case in the past, it is reasonably certain that the pressure of international competition is going to advance those individuals of experience and ability of a practical kind. There are, moreover, thousands of men now higher up the ladder who formerly filled skilled posts in the

shop and drawing office. So there actually is reward for a large proportion after all. Those who remain have interest in their occupation and the respect of everyone in the business: no small compensations in any assessment or comparison.

THE LUMEN UNIT OF ILLUMINATING POWER.

The term "lumen," proposed by A. Blondel in the past century, has become familiar to scientists, but has not gained much favour with the public. People understand what light a 16-candle lamp will give, but the lumen does not convey anything to them, and when they hear that the definition of the lumen involves the term spherical candle-power, they naturally object to being bothered with a new name for something which they had learnt to understand in another sense. The answer of the scientist is that candle-power is an inadequate and indefinite term, because there are several candle-powers, that spherical candle-power does not mean what it is frequently believed to signify, and that under such conditions it is best to introduce an altogether new, preferably foreign, name to put an end to misunderstanding. To speak of lumen or of flux of light conforms, moreover, to modern conceptions about radiations, and popular expressions such as a lamp "shedding light" and "floods of light" indicate that the common conception of light is indeed that of a flux and not of an illumination. This was pointed out by Mr. C. C. Paterson in March, 1915, when the Illuminating Engineering Society discussed the "lumen" for the second time, the first time having been in May, 1914.

The question came up for the third time in the meeting of the same society held on January 16th, and the general adoption of the lumen is no longer doubtful. On the second occasion Mr. A. P. Trotter had pleaded for the retention of the candle-power, mainly, probably—we do not remember his words—because it meant something to those directly interested, the lamp maker and buyer. Meanwhile, however, illumination as a science has been making strides, the leading electric companies and others offer lumens instead of candles, and the public must in such matters be guided by the scientific expert. The chief papers presented in the last meeting were by Professor J. T. Morris, of the East London College, and by Mr. F. W. Willcox, of the British Thomson-Houston Company. The latter had taken pains, by preparing many diagrams, to explain the inadequacy of the candle-power and the advantages of the lumen. To speak of candle-power is like speaking of the pressure of a pump; what one wants to know is the output of light and of water. The amount of water that a lake can yield might be measured by drawing a line across the lake and measuring the depth along that line—provided the basin were regular, and all the lakes in question were of the same shape. If a ditch were excavated along that line the depth would be much increased, but the capacity of the lake very little. Similarly the candle-power of a lamp can be increased by turning part of the globe into a reflector, and the candle-power depends much on the number, distribution, thickness and shape of the filaments. As that is fully recognised, of course, the mean spherical candle power—M.S.C.P.—is stated instead of horizontal candle-power or the power at a certain angle. But the M.S.C.P. is difficult to determine and to interpret, just as difficult as the lumen, and one might, therefore, go one step further and adopt the lumen.

The lumen is practically defined as the flux of light received by a surface of 1 square foot, when under an illumination of 1 foot-candle over its area. The flux of light emitted by a source is 4π times its M.S.C.P.; 4π is equal to 12.57. Thus a 50-watt tungsten lamp operating at 0.8 candle per watt. (or 1.25 watts per candle-power) yields approximately 500 lumens. The lumen, therefore, is, in a sense, nothing but a multiple (12.57 times) of the mean spherical candle-power. But we can speak of light flux or lumens per zone of 10 degrees, whilst it would be very cumbersome to express our meaning in M.S.C.P. A source of light of 1 candle suspended in a sphere of 1 foot radius would shed one lumen over each square foot of that surface, and as the total surface is $4\pi \times 1^2 = 12.57$ sq. ft., the total light flux will be 12.57 lumens. When the source is not a point the lumens have to be determined in different zones; the sum of these determinations gives the total lumens emitted by the lamp. When the determinations are subsequently repeated for the lamp as fitted, in a particular case, with globe, reflector, &c., we find the lumens available upon a certain area as per cent. of the total; this percentage is the "utilisation efficiency," which will also depend upon the colour of the ceiling and walls and other circumstances. When a room is to be lighted, the area in square feet A is multiplied by the desired intensity in foot-candles C; the product gives the net lumens required. To arrive at the total lumens L, that figure has to be divided by the utilisation efficiency E. Knowing the total lumens, the illuminating engineer consults the lumen tables of various sizes of lamps; the number of lamps required is then the quotient AC/EL.

There was no real opposition to the adoption of the lumen. Mr. A. P. Trotter rightly emphasised the need of a proper definition of the lumen, and the Illuminating Engineering Society resolved, on the suggestion of its honorary secretary, Mr. L. Gaster, to issue a pamphlet explaining the use and value of lumen rating. In the definition of the lumen we quoted above, after Professor Morris, use was made of the foot and the foot-candle. But the lumen is really independent of the system of measures, and would be same if feet were replaced by metres; the factor falls out in the calculations. The unit of intensity of light, the international candle, is, and has been, for some years the same for Great Britain, France and the United States. Thus the objection is met that the present adoption of the lumen would probably necessitate a further, though slight, change when the British system of measurements will abdicate in favour of the metric system, a change that the war is hastening on. Until a few years ago the British candle was not quite the same as the United States candle; it was also a little smaller than the Hefner candle, very slightly larger than the unit of the Laboratoire Central d'Electricité at Paris, and only a tenth, roughly, of the Bec Carcel. But those differences disappeared when the three States mentioned adopted the "international candle," and it seems very likely that the international candle will really become international, and that the continental nations will adopt the lumen rating. Many American lamp makers have done this, and Professor Blondel informed the meeting in writing that the Société de Physique de France and the Société de Electriciens favoured this adoption.

POTASH FROM THE BLAST-FURNACE.

The recovery of potash as a by-product from the blast-furnace and blast-furnace gas has repeatedly been proposed, but Mr. R. J. Wysor, superintendent of blast-furnaces of the Bethlehem Steel Company, is probably the first who has attacked the problem on a practical scale. Four years ago Mr. Wysor, while investigating the efficiency of blast-furnace stoves, analysed the yellowish fume dust from the bottom of the stove checker-work. He was surprised to find 15 per cent. of water-soluble potash in this dust, and that induced him to start a practically novel investigation, in order to trace the potash and soda unintentionally fed into the blast-furnace in the raw materials through the various furnace processes. Though importance has been attributed by some metallurgists to the action on the iron of the alkali cyanides formed in the furnace, the alkalis themselves have received little study by iron smelters, and there is hardly any direct literature on the subject. The quantitative determination of the alkalis is laborious. Mr. Wysor describes the researches, which involved a very large number of analyses made by Mr. F. O. Kichline, the chief chemist of the works, in the Bulletin of the American Institute of Mining Engineers, January, 1917, pages 1 to 32. Several curious observations were made incidentally during the investigation.

From analyses of carloads of raw materials it resulted that the iron ore used at Bethlehem contained about 0.3 per cent. of potash and 0.7 of soda; in the manganese ore the potash percentage rose over 1, but the coke and the lime and magnesia of the flux reduced the averages of the K_2O and Na_2O in the total furnace charge to 0.28 and 0.63 per cent. In the slag were found 0.39 per cent. of K_2O and 0.56 of soda. In the crevices of slag dumps yellow-white salt deposits were noticed; they contained up to 18 per cent. of K_2O, only half as much of soda, a great deal of lime and sulphur, but no magnesia at all. Thus the K : Na ratio was reversed in the slag, and the absence of magnesium salt (very soluble, of course) was equally curious; evidently the magnesia had helped very little in desulphuring the iron. Deliquescent crystals that had settled on burnt-out jacket plates were essentially ammonium chloride, free of cyanides; the liquid exuding from these cooling plates and their stalactitic salt masses were richer in K and Na and in cyanides. In the firebricks of old furnaces the alkali percentage had risen from 1.6 (originally) to 3.4 and higher. Much alkali escaped with the dust and fumes and furnace gas. Cyanogen compounds, formed in the furnace by the interaction of alkali, carbon, iron and nitrogen, are supposed to dissociate in the upper portion of the furnace. But Mr. Wysor quotes the case of the Hieflau blast-furnace (charcoal) in Styria, where, in 1901, 2,800*l.* had to be paid in damages for discharging 20 tons of furnace-flue dust into a river, in which all the fish were killed.

At Bethlehem the blast-furnace gas leaving the dust catchers is washed in spray towers. It was found that the washing left 20 per cent. of the K_2O and 5 per cent. of the Na_2O in the gas, the fumes being evidently too fine to be absorbed by the coarse spray. The dust accumulating in two or three months in the gas mains leading from the washers contained 44 per cent. of K_2O. The stoves in use are of the three-pass type; the volatile constituents are expelled from the wet dirt, while an impalpable powder collects in the bottom of the combustion chamber and in the checkers, and a large portion of the gas is carried out into the gas stack. In the combustion chambers all the bricks were found glazed deep green or badly honeycombed, the corrosion being particularly marked along the joints. In the glazed slag 18 per cent. of potash and 8 of soda were detected, against 0.25 per cent. of alkali in the original brick. The fine, light-coloured dust collecting in the second and third passes is the chief material for potash extraction; the passes are cleaned every three or four months. A similar dust accumulates in the boiler-house, and is recovered every few days from the passes and also from the flues. Some of the dust forms a light friable sinter, other dust is exceedingly fine; drawn hot from the boiler settings, the latter runs like mercury. The dust was found to contain from 5 to 20 per cent. of potash soluble in water. These extraction experiments began at Bethlehem in 1914. From April, 1915, to July, 1916, the dust was collected from the stoves and boilers serving four 500-ton furnaces. The composition of this dust, aggregating a little over 1,000 tons, varied greatly, of course, and not only with respect to the soluble alkalis, as first indicated. But the dust always contained about 20 per cent. of silica, 11 of alumina, 12 of lime, 9 of magnesia, 7 of sulphuric acid and 4 of chlorine, but neither ammonia nor cyanogen compounds; these would be destroyed by the roasting the dust had undergone. The alkali escaping with the gas from the stacks was also determined; such gas has the appearance of a white fume, but in dirty gas the whitish fumes are obscured.

The balance-sheet drawn up by Mr. Wysor shows that of the total potash entering the furnace, 20 per cent. was lost in the slag, 2 per cent. lost in direct fumes from the furnace, 3.9 per cent. escaped with the gas, 2.7 per cent. was recovered in the dust-catchers, 60 per cent. lost in the primary washers, 2 per cent. lost in the secondary washers, 1.3 per cent. lost in stove and boiler passes, and 11 per cent. lost in stack gases; the losses of soda in the primary washers were even greater than those of potash. The losses in the primary washers were estimated by difference, and probably overrated. The amounts of potash and of soda actually recovered were 1.3 and 0.3 per cent. of the totals. That is an almost insignificant figure. What we have said does not exhaust the experiments made, however. Part of the gas, directly from the dust-catchers,

was treated in electric precipitators by the Cottrell process, and practically cleared of dust in this way; about 10 per cent. of potash was found in this dust. The treatment is described as having been successful, but particulars are not given. The potash recovery might be further raised by treating the dust with weak acid, instead of leaching it merely with water; that process does not look promising, however; and whether anything can be done with the exceedingly complex slags and the alkali in them is a big question. On the other hand the thorough dry-cleaning (by electric precipitation) of the gas would in several respects be preferable to the usual wet-cleaning of blast-furnace gas.

In this connection one of the points incidentally cleared up deserves mention. Complaints arise occasionally that blast-furnace gas will not burn, or burns streakily and incompletely. Such gas is known in America as "calico," or smoky gas; it seems to be of normal composition, so far as ordinary analysis goes, and the trouble may last a few seconds or several hours. Mr. C. H. Rich, of the Alan Wood Iron Company, informed Mr. Wysor that the smoky gas was rich in salt fumes and would burn properly when the fumes were eliminated. Mr. Wysor tested the problem by preparing powders, more or less fine, of the chlorides and cyanides of potassium and sodium, and by spraying these powders by compressed air into the gas nozzle. The coarse salt grains (40-mesh) had no influence at all on the flame; but the finest salt dust (100-mesh) stifled the flame and produced the smoky appearance.

Several American blast-furnace plants have already taken up potash recovery on the suggestion of the Bethlehem works. But the potash percentage in the Bethlehem ores appears to be above the average. Whether those experiments would survive the restoration of normal potash prices after the war, simply for the sake of recovering a paying by-product, certainly looks doubtful. But it is to be hoped that something will result from the endless papers and discussions on scientific methods of manufacture, the prevention of waste, and the husbanding of natural resources.

SOAP BUBBLES OF LONG DURATION.

THE season of the Royal Institution evening discourses was opened on Friday, January 19, at 5.30 p.m., by Sir James Dewar, F.R.S., Fullerian Professor of Chemistry, who has delivered the first discourse for a long series of years. As was the case last year,* he lectured on capillarity phenomena, but this year he made "Soap Bubbles of Long Duration" directly the title of his discourse. Longevity, Sir James remarked, could only be demonstrated by registers, and he pointed to the bulky notes in which his observational records were entered. Last year he had dealt with the finest soap films, which, when produced in an atmosphere containing nothing but water vapour—no air—could easily be preserved for many months. The large glass bottle containing the horizontal films shown in January, 1916, was on the lecture table; the "black" film, only visible in reflected light, was still intact. The study of soap bubbles introduced further difficult problems; there were the difficulties of internal gas pressure and of the transference of gas from the inside of the bubble, in addition to the primary difficulty of isolating one particular bubble for the examination to which he had submitted films. Why had he taken up these studies, Sir James asked. Years ago he had lectured on soap bubbles, and he had then been fascinated by the wonderful work of Joseph A. F. Plateau, of Brussels, Professor of Physics at Ghent, who had entered upon the investigation of soap bubbles in 1842, when 40 years old, and practically blind owing to his experiments on the action of intense light on the retina. Plateau was also a painter, and that had helped him to continue his researches with the aid of assistants till he died, when nearly 80 years of age.

When soap bubbles were blown in air, Sir James continued, the air should be free of dust. The part played by the impurities of the air in putrefaction had been discovered by Pasteur, and Tyndall had later demonstrated the gross impurity of the air and its purification in very valuable ways. Sir James concentrated the beam of an arc lamp by a lens; a whitish cone of light was seen in the impure air of the lecture theatre, but when the many organic particles in that dust were burnt by placing a burner under the beam, peculiar black shadows of "optically pure" air were noticed moving in the beam. Tyndall had further purified the air in glass boxes by smearing the glass with glycerin; in Tyndall's box exhibited, into which air was admitted through cotton-wool filters, no putrefaction had taken place, and the Tyndall effect test for dust-free air—invisibility of a strong beam of light—was well known. Sir James further demonstrated it by some novel experiments. He sent a beam of light upward through a glass bottle containing ordinary air; when a blast of air which had been strongly compressed (for subsequent condensation and liquefaction), and thus been heated, was passed through the bottle, the beam became much fainter. He also placed the electrode of a Wimshurst machine axially in the beam, the bottle in this case having been filled with smoke from some burnt bituminous matter; after the machine had been worked for a few minutes the air clarified and shadows of black were seen to develop in the beam. Illuminated by the arc, the space inside a big soap bubble, blown in pure air, within a glass case, looked dark. Ordinary London air, Sir James explained, contained about 100,000 particles of organic and inorganic matter, often greasy, per cubic centimetre. A speck of grease on a soap bubble would, of course, affect the surface tension of the bubble and make it break down. It was astonishing that people should have blown bubbles for 50 years after Plateau, in the open air, without suspecting the air; but, Sir James added, he had not particularly referred to this point last year because he had not known it himself then.

As regards the soap solution, Plateau had used a 2 per cent. solution of olive-oil soap containing 30 per cent. of glycerin. For his own experiments, in which he measured and weighed and tested, Sir James sometimes used high percentages of glycerin, and he preferred the purest oleic acid (tested by the iodine number) and ammonium (not potassium or sodium) soap, because there was a very sensitive reagent for ammonia (Nessler's—mercuric iodide gives, with a trace of ammonia, a reddish-brown precipitate or colour, as demonstrated), with the aid of which the disappearance of ammonia from the film could be followed. The bubbles were blown in purified air, by opening a stop-cock in the air supply tube, or with the mouth. Liquid air might be used, of course, but it would have to be heated up first; ordinary air used for blowing was filtered through cotton wool; several devices for this purpose were shown. Bubbles could be blown hanging or resting (upon a wide ring, for example). The little bubble or sac of liquid at the bottom of a bubble could be removed by suction through tubes applied from outside (the tubes used in blowing), or tubes passed from above axially into the bubble. Properly drained, the bubbles lasted a long time; but bubbles were more sensitive to tremors than films. Some of the bubbles exhibited were nearly ½ m. in diameter; they were blown in cubical or oval glass vessels containing pure air at atmospheric pressure. Some water was always kept in the bottom of the containing vessel.

The experiments which Sir James then briefly outlined with the aid of slides concerned the life of bubbles, the changes in the diameter of the bubble (spontaneous contraction) and in the liquid forming it, and the transference of gas through the skin of the bubble from the inside to the outside of the bubble. His first bubble by the improved processes had only lived three days, but the life had soon been prolonged; a bubble 20 cm. in diameter had held out 95 days, one of 40 diameters 63 days, smaller bubbles nearly a year. A uniform cool temperature (about 10 deg. C.) favoured longevity. The freshly blown bubble, we might perhaps interpose, shows, of course, an irregular streaming of the liquid in the film; as the excess of liquid drains off the visible motion ceases, the bubble thins out and becomes black in the upper portion, whilst coloured rings appear near the bottom, in which streaming may still be observed. At the same time the "condensation" sets in, of which Sir James spoke Water vapour was absorbed by the glycerin of the bubble; the bubble solution was thereby diluted, but the film still remained thick enough to display colours. This condensation was watched by periodic analyses of the drops falling from the bubble, which were collected in a graduated tube leading out from the containing vessel. The condensation amounted, for example, to 0.412 milligramme on the first day and, decreasing rapidly, to 0.003 milligramme on the 20th day, the weights named being per square centimetre per day. Only 2 or 3 per cent. of the glycerin originally in the solution might be left in a fortnight, and in this way 90 per cent. of the soap had been washed out in 20 days.

Owing to the surface tension in the film there was further contraction of the bubble, accompanied by the transference of gas through the film outward. The rate of the contraction and transference varied with the gas; it was much more rapid with hydrogen than with air; a hydrogen bubble would be blown in hydrogen at atmospheric pressure. The contraction of the diameter increased more rapidly as the time advanced and the diameter became smaller, the curve, diameter plotted against time, being parabolic. The internal pressure varied inversely as the diameter. In a diagram exhibited the diameter of a bubble diminished from the value 1 to 0.2 in 24 days; in the case of a black bubble the diameter had been reduced from 38 to 1.5 cm. in five weeks. Black bubbles best showed this contraction, which depended upon the thinness of the film and the dilution of the solution; but it was very well observable also in coloured bubbles. The gas transference amounted to 0.023 cub. cm. per square centimetre per day in one case quoted. Finally, Sir James Dewar exhibited a series of coloured photographs which brought out well the gradual colour changes and the beautiful colours displayed; in some of these photographs the sharp boundary lines of the black zone and of the silvery zone and the coloured rings were quite distinct; others exemplified more the gradual transition of pink into green, &c. Peculiar colour effects were seen in the bubbles and in these photographs when the illumination was by mercury-vapour lamps.

Concluding, Sir James made a few remarks which will find a warm echo in wide circles. The study of soap bubbles was by no means ended, he said. But it was a question whether the laboratories of the Royal Institution could continue to exist. He was practically restricted to two assistants now, and one of these might be called up any day. The Royal Institution had been founded more than a hundred years ago, in the time of England's deepest depression. The present demand for technical advance threatened to submerge pure science; he did not like the term "pure" science, but utility was not the highest aim of science. Low-temperature research was being continued in Germany. The demonstrations were in charge of Mr. W. J. Green, B.Sc., and Mr. J. W. Heath, F.C.S.

* See ENGINEERING, January 28, 1916, page 87.

NOTE.

SOUND TRANSMISSION, REFLECTION AND ABSORPTION.

ACOUSTICALLY architectural and engineering structures cannot be said to excel, and the builder may justly complain that scientists do not give him much guidance as to the acoustical behaviour of his materials and structures. In his experiments on the transmission, reflection and absorption of sound, Professor F. R. Watson, of the University of Illinois (*Physical Review*, vol. vii, pages 125 to 132), made use of the following arrangement. He placed the source of sound in one room, and the receiver in another, the two rooms communicating by a door. The source was an adjustable whistle blown by air at constant pressure and mounted in the focus of a parabolic reflector. The receiver was a Rayleigh resonator in which a mica plate, suspended by a quartz fibre at 45 deg. to the direction of the sound, was turned more or less about its vertical axis by the arriving sound waves. The waves travelled through the door, which was either open, or closed by one or more superposed panels of the respective material. The deflections observed were not steady, and some peculiar observations were made. With the door open the deflections amounted to about 40 divisions, measured by a cathetometer. When the

door was closed by the panels the deflections were, of course, smaller; but several layers of the same material had not always the effect to be expected from measurements made on one layer. Thus the deflection with one layer of different materials, ½-in. hair felt, ½-in. cork board, ½-in. cork board, ½-in. paper-lined hair felt, ¾-in. of same, ¾-in. flax board, ½-in. pressed fibre, ¾-in. of same, were, respectively, 22.6, 7.9, 1.15, 5.0, 6.5, 2.25, 0.32, 0.2, so that one layer of hair felt stopped least of the sound (only 43 per cent.), whilst the cork board stopped 80 and 90.5 per cent., and the pressed fibre barred practically all the sound. But the figures for one, two and three layers of hair felt were 22.6, 15.4, 10.4; for ¾-in. cork board, 1.15, 2.05, 0.85; for ½-in. lined hair felt, 5.0, 21.7, 3.8; and for ¾-in. lined hair felt, 2.25, 0.55, 0.1. Thus two layers of cork stopped less sound than either one layer or three layers, and two layers of the ½-in. paper-lined hair felt behaved still more abnormally compared with one and three layers of the same material. The further investigation showed that reflection, absorption, resonance, and other effects come in. To study these the sound was sent obliquely towards the door; the reflected sound was measured, and the absorbed calculated by difference, assuming that the sound can only be transmitted, reflected or absorbed, and that the three fractions together ought to make up the unit value of the whole incident sound. Arranging the materials as before, the following reflections were observed, again for one, two and three layers: hair felt, 19, 25, 40; ½-in. cork, 61, 55, 87; ¾-in. cork, 100, 82, 85; ½-in. paper-lined hair felt, 80, 23, 39; ¾-in. same, 40, 25, 36; ¾-in. flax board, 87, 77, 77. The amount of sound reflected and absorbed increased in most cases with the thickness, while the transmission decreased. But in the ½ in. paper-lined hair felt reflection and transmission followed each other closely (as Professor Watson's curves clearly indicate), both being anomalous, and that is probably accounted for by resonance; certain thicknesses of the materials vibrate vigorously under the action of the sound, setting up new waves. This explanation was suggested in similar researches made by a different method in 1910 by Weisbach; porosity, density and elasticity of the material have to be considered. Porous bodies like hair felt probably transmit sound like air, and a denser material stops more sound than the same thickness of a less dense material. Thus pressed fibre cuts off the sound better than the same thickness of oak. Elastic materials vibrate in resonance to the source, creating sound waves of the same character on the further side. Hence they act as if there were no partition wall. The two thicknesses of paper-lined hair felt probably approximated such a vibration.

THE LATE MR. G. A. HOBSON.

We regret to have to record the death, in his sixty-third year, of Mr. George Andrew Hobson, M.Inst.C.E., who was for many years a partner with Sir Douglas Fox and Sir Francis Fox, and played an important part in the extensive work which the firm have carried out, particularly in South Africa in association with Sir Charles Metcalfe, Bart. Alike in such extensive works as the construction of a trunk line like the Great Central Railway as in pioneer work in Rhodesia, Mr. Hobson's skill, particularly in bridge designing, was of immense service. He brought to bear on such design work not only thorough scientific knowledge, but intimate acquaintance with practical methods, while his innate love of beauty of form ensured a close approximation to artistic fitness. There was no unnecessary expenditure of metal, while the details were such as to facilitate transport in new countries and rapid construction with the minimum of handling plant. Perhaps the best example of his work, from all three standpoints, is the bridge spanning the Zambesi River, near to the Victoria Falls.

Mr. Hobson's training admirably conduced to this efficiency. Born at Leeds on March 29, 1854, the younger son of the late Mr. Peter Hobson, of Knaresborough, he received his early education at King's College School, Knaresborough, and went, when 14 years of age, to Edinburgh, where resided his uncle, the late Sir James Falshaw, Bart., and under his care he went through a three years' academic course, devoting himself specially to mathematics and physical science, at the Watt Institution, now incorporated with the Heriot-Watt College, in Edinburgh. When 17 years of age he was apprenticed to the firm of Hopkins, Gilkes & Co., now the Teesside Iron and Engine Works Company. Well equipped mentally, he was at an age when he could enter with enthusiasm upon a course of practical instruction in engineering, and he took full advantage of his opportunities. He passed successfully through the drawing office, the pattern shop, the fitting and smith's shop, the bridge and boiler yard, and the blast-furnace and rolling mill shops. No fuller course for the acquisition of experience with regard to constructional steelwork could be conceived, and that he had made full use of his time is shown by the fact that when 20 years of age—even before the completion of his period of pupilage—he was placed in responsible charge of the construction of new blast-furnace works for the firm. On their completion he took over all designing work as chief of the drawing office, and there he continued for five years.

It was in 1880, when 26 years of age, that he became chief assistant to Sir Douglas Fox, and 20 years later became a partner, retiring in 1912. Thus for 32 years he was responsible directly for the design of the bridges, stations and constructional steelwork generally on the many railways and other work of which Sir Douglas Fox and Partners were engineers. Amongst the home lines were the West Lancashire Railway, the Southport and Cheshire Lines Extension Railway, the Scarborough and Whitby Railway, the Mersey Railway, including the tunnel, the Gravesend Railway, the Wirral Railways, the Manchester, Sheffield and Lincolnshire Wigan Extension Line, and the Liverpool, Southport and Preston Junction Railway. He also took a prominent part in the design work for the Overhead Electric Railway of Liverpool, and it was in connection with this that he brought out his patent flooring, which is still known by his name, and which solved a difficult problem, not only connected with this railway but with many others. Of its value, the best testimony is to be found in the fact that well over 100,000 tons of this system of decking for bridges, piers and warehouses is employed in various parts of the world. He was associated also with the Hawarden swing bridge over the River Dee at Connah's Quay, near Chester, with the rack railway up Snowden mountain, and with large granaries at Liverpool.

Elliott and Fry, Photo.

The late Mr. G. A. Hobson.

Perhaps, however, the most extensive work done at home in recent years was in connection with the construction of the line connecting the Manchester, Sheffield and Lincolnshire Railway with the Metropolis, a line now known as the Great Central. Sir Douglas Fox and partners were responsible for the southern part of the line, extending from about Rugby to London and including the Marylebone terminus. The constructional steelwork was particularly heavy, notably in the metropolis, as there was here also constructed an immense warehouse. This, one of the most extensive railways built in recent times in this country, has been fully described in Engineering, and the work at the metropolitan terminus was the subject of a paper read in 1900 by Mr. Hobson and his colleague, Mr. E. Wragge, at the Institution of Civil Engineers, for which both authors received the Telford medal and premium. In connection with the tube systems of London he played an important part, and was engaged, along with Sir Douglas Fox and Partners, on the Great Northern and City Railway from Finsbury Park to Moorgate-street, and on the Charing Cross, Euston and Hampstead Line, his firm being associated in the latter with the late Mr. W. R. Galbraith.

Mr. Hobson was responsible for extensive work in several foreign countries, and paid visits to Russia, the United States, Canada and South Africa. He was associated with railway work in India, Argentina and Colombia and other countries, and with extensive granaries at Buenos Aires; but it was in South Africa that his work abroad was most extensive and beneficial. Much of the bridge and constructional steelwork on the lines connecting the Cape Colonies with Rhodesia, totalling in all over 2,500 miles of railway, was designed by him. As we have said, one of the finest examples of his work is the bridge over the Zambesi River. It is notable as having the greatest combined height and span of any similar structure yet built, the central span of 500 ft. having a rise of 90 ft., while the height from low-water to rail level is equal to that of St. Paul's Cathedral from the floor to the top of the cross. It carries two lines of rails, the width at track level being 27 ft. 6 in., centres of girders, and at the springing level 53 ft. The bridge, and the problems involved in its design, were the subject of a paper read in 1907 by Mr. Hobson at the Institution of Civil Engineers, and it may be taken by young engineers as a model not only for the evidence of the characteristic introspection of the author, but for the freedom with which problems are discussed and information given. Indeed, it brought high encomiums from American engineers, alike for the paper and for the work it described. For this contribution Mr. Hobson was awarded the Stephenson medal. Another notable bridge was that over the Kafue River in Rhodesia. The details of the proposed plan to bring the water-power of the Victoria Falls to work the gold mines of the Rand by hydro-electric installations were also worked out by him, and he was responsible for the designs for the port of Beira and other important works for the Chartered Company of South Africa.

The subject of our memoir became an associate member of the Institution of Civil Engineers in 1883, and was promoted to full membership in 1885. With the exception of the two papers mentioned, for each of which he received a gold medal, he took little part in public life. He contributed occasional articles to the technical press. Privately, he did much good unobtrusively, and there are many who could bear testimony to his large-hearted generosity, his wise and kind advice, and his far-seeing judgment. Kindly by nature, he gave of his best for the encouragement of young men in various stations of life, and many successful engineers to-day owe much to his guiding influence. He had many interests apart from engineering, and in certain branches of philology, heraldry and antiquarianism found relaxation. He was a wide reader. He wrote a life of his uncle, Sir James Falshaw, Bart., his mother's brother, through whom he came of the old stock of the Falshaws of Langstrothdale, dating back to 1399. He was a great lover of nature and of country life and pursuits, and his chief enjoyment was found day after day in the depths of the country, alone with Nature, studying bird life. A most congenial duty he undertook was extensive works upon the estate, in Kent, of Mr. Wm. Waldorf Astor.

Mr. Hobson retired from business in 1912, owing to ill-health, but he continued for quite three years longer the most serviceable work he was able to do, from his wide knowledge, of structural steelwork especially, on two of the Engineering Standards Committees. His health, however, ultimately compelled him to relinquish even this pleasant association, and he died, somewhat unexpectedly, on the 25th ult., at his home, Coverdale Lodge, Richmond, Surrey, in his 63rd year. His widow—Annie Jean, the only daughter of Thomas Addyman, of Belmont, Yorkshire, to whom he was married in 1882—with her only child (a daughter), have the deep sympathy of many professional and social friends. Many showed respect for his memory by attending his funeral at Richmond cemetery on Monday last.

By-Product Coke Plants in the United States.—We read in the *Iron Trade Review*, Cleveland, Ohio, that there were 6,756 by-product ovens in the United States on September 1, 1916. The annual consumption of coal amounted to 29,827,000 net tons. On September 1, there were 2,236 by-product ovens under construction and, when completed, these will consume 13,867,000 net tons of coal per year. The total coke output of completed plants is 22,479,400 net tons per year, while the plants being built on September 1 will have a capacity of 10,126,000 net tons per year.

LLOYD'S RESPONSIBILITY FOR VESSELS BUILT TO LLOYD'S REQUIREMENTS.

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the article upon the case of the Australind Steam Shipping Co., Limited, *v.* Devitt and others, which appeared in your issue of the 26th instant, page 82, as this case is of particular interest to the shipping community, our clients, the Committee of Lloyd's Register of Shipping, who were the defendants, desire us to state that they entirely denied the allegation of negligence and were prepared with evidence of eminent experts in support of such denial. This evidence was not given because the learned judge held that the plaintiffs failed on their own evidence to prove the existence of any contract between themselves and the defendants, or of any duty owing from the defendants to the plaintiffs. It was therefore unnecessary to hear the defendants' evidence.

The learned judge, in giving judgment, said, "I must not be thought to be in any way deciding, nor must it be thought that it is in any way being decided, that the facts as proved by the plaintiffs constitute negligence."

We shall be much obliged if you will kindly insert this letter in your next issue.

Yours faithfully,
PARKER, GARRETT AND CO.

St. Michael's Rectory, Cornhill, London, E.C.,
January 29, 1917.

CUTTING AND CHIPPING OF GLASS.

TO THE EDITOR OF ENGINEERING.

SIR,—With all its advantages, the division of labour, so much accentuated in modern times, tends to carry with it a regrettable division of information. Much that is familiar to theorists and experimenters in laboratories percolates slowly into the workshop, and, what is more to my present purpose, much practical knowledge gained in the workshop fails to find its way into print. At the moment I am desirous of further information on two matters relating to the working of glass in which I happen to be interested, and I am writing in the hope that some of your readers may be able to assist.

Almost the only discussion that I have seen of the cutting of glass by the diamond is a century old, by the celebrated W. H. Wollaston (Phil. Trans., 1816, p. 265). Wollaston's description is brief and so much to the point that it may be of service to reproduce it from the "Abstracts," p. 43:—

"The author, having never met with a satisfactory explanation of the property which the diamond possesses of cutting glass, has endeavoured, by experiment, to determine the conditions necessary for this effect, and the mode in which it is produced. The diamonds chosen for this purpose are naturally crystallised, with curved surfaces, so that the edges are also curvilinear. In order to cut glass, a diamond of this form requires to be so placed that the surface of the glass is a tangent to a curvilinear edge, and equally inclined laterally to the two adjacent surfaces of the diamond. Under these circumstances the parts of the glass to which the diamond is applied are forced asunder, as by an obtuse wedge, to a most minute distance, without being removed; so that a superficial and continuous crack is made from one end of the intended cut to the other. After this, any small force applied to one extremity is sufficient to extend this crack through the whole substance, and successively across the whole breadth of the glass. For since the strain at each instant in the progress of the crack is confined nearly to a mathematical point at the bottom of the fissure, the effort necessary for carrying it through is proportionately small.

"The author found by trial that the cut caused by the mere passage of the diamond need not penetrate so much as $\frac{1}{250}$ of an inch.

"He found also that other mineral bodies recently ground into the same form are also capable of cutting glass, although they cannot long retain the power, from want of the requisite hardness."

I suppose that no objection will be taken to Wollaston's general description of the action, but it may be worth while to consider it rather more closely in the light of mathematical solutions of related elastic problems by Boussinesq and Hertz; at the same time we may do well to remember Mr. W. Taylor's saying that everything calculated by theorists is concerned with what happens within the elastic limit of the material, and everything done in the workshop lie beyond that limit. A good account of these theoretical investigations will be found in Love's "Elasticity," chapter viii. It appears that when a pressure acts locally near a point on the plane surface of an elastic solid, the material situated along the axis is in a state of strain, which varies rapidly with the distance from the surface. The force transmitted across internal surfaces parallel to the external surface is a *pressure* all along, but the force transmitted in a perpendicular direction, although at first a pressure, at a very small distance below changes to a *tension*, which soon reaches a maximum and afterwards gradually diminishes. I suppose it is this tension which determines the crack, an action favoured by the longitudinal character of the pressure on the surface, and, once started, easily propagated as the diamond travels. Doubtless cutters of hardened steel discs, sharpened on the edge, act in a similar manner. It is possible that examination under the microscope by a skilled observer would throw light upon the matter. Among the questions which suggest themselves, one may ask whether the diamond cut necessarily involves a crushing at the surface, and what materials, besides glass, can be dealt with in this way. Would a bending force, such as is afterwards applied to separate the parts, facilitate the original formation of the crack?

The other matter in which I have been interested is the preparation of what I believe is called "chipped" glass. The only mention of it that I know is a casual one in Threlfall's "Laboratory Arts." In an experiment tried some years ago, a glass plate was coated thickly with a warm solution of gelatine and allowed to dry on a levelling stand. Nothing particular happened afterwards for days or weeks; but eventually parts of the gelatine film lifted, carrying up with them material torn away from the glass. The plate is still in my possession, and there is now but little of the original glass surface left. If the process is in regular use, I should much like to know the precise procedure. It seems rather mysterious that a film of gelatine, scarcely thicker than thick paper, should be able to tear out fragments of solid glass, but there is no doubt of the fact.

Yours truly,
RAYLEIGH.

THE SPECIFIC HEAT OF SUPERHEATED STEAM.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with very great interest the editorial in your issue of December 15, on the "Specific Heat of Superheated Steam," and am pleased to note the excellent result that has been obtained in Professor Callendar's laboratory by Mr. Brinkworth. Will you permit me to call your attention, as a matter of mutual interest, to the results of experiments which were carried out, under my direction, in Cornell University, and which I recorded as part of a discussion on the paper by Professor R. C. Carpenter, entitled "Steam Plant of the White Motor Car"? The paper and the discussion will be found in vol. xxviii, Transactions, American Society of Mechanical Engineers, 1907. The curves, showing comparison between our results and those of Professor Callendar at that time, are given on page 602 of the volume in question, and the description of the experiments begins on page 611. The value of the specific heat from our curves agrees almost exactly with the value reported by Mr. Brinkworth. The data for the Cornell tests are on file in Sibley College.

As a part of the same discussion, a brief description is given also of the electric steam calorimeter, the invention of which grew out of the experiments on specific heat.

I beg to remain, yours very truly,
C. C. THOMAS.

Baltimore, Maryland, January 4, 1917.

[The discussion to which Professor Thomas refers will be found in the December issue of the Proceedings of the American Society of Mechanical Engineers for 1906, not 1907, as given in his note. A fuller description of his apparatus and observations was given in a subsequent paper presented to the same society and reprinted in our issue of March 27, 1908.—ED. E.]

ELECTRON, QUANTA AND RELATIVITY THEORIES.

TO THE EDITOR OF ENGINEERING.

SIR,—As an answer to "Sesamy's" first paragraph, I will quote Maxwell's "Theory of Heat" (1888), page 257:—"The quantity of heat which enters any portion of the body may be greater or less than that which escapes from it." With regard to the second paragraph, the temperature of interstellar space has been calculated at rather less than 10 deg. A. As to the third paragraph, I have not used the phrase "matter and motion" in a sense different from Maxwell, with whose notion of energy as matter in motion I entirely agree.

In continuation of my letter in your issue of January 19 I should like to discuss a specific instance of what I consider to be the unconscious distortion of fact by means of mathematical theory, and I cannot do better than refer to J. H. Jeans's "Electricity and Magnetism" (2nd edition, page 488), where he refers to Hamilton's principle as follows:—"Equation (496) has been proved to be true only for a system consisting of discrete material particles. At the same time the equation itself contains in its form no reference to the existence of discrete particles. It is at least possible that the equation may be the expression of a general dynamical principle which is true for all systems, whether they consist of discrete particles or not. We cannot, of course, know whether or not this is so. What we have to do in the present chapter is to examine whether the phenomena of electric currents are in accordance with this equation. We shall find that they are, but we shall, of course, have no right to deduce from this fact that the ultimate mechanism of electric currents is to be found in the motion of discrete particles." Whereas (quoting from memory) Maxwell, in a somewhat similar case, summarily settled the matter by saying that in the case of action at a distance certain terms relating to the medium became irrelative. It may be added that Professor Jeans has a far lesser right to imply, as he virtually does, that the ultimate mechanism of electric currents is *not* to be found in the motion of discrete particles.

This is the fallacy around which modern Cambridge text-books are written. Personally, I prefer for preliminary study Tarleton's "Theory of Attraction," vol. ii, because it honestly points out that some of these theories rest upon insecure foundations, and that the equations of Maxwell's electromagnetic theory of light are so general in their character that when they are applied to cases of reflection and refraction they fail to have any physical import.

Scientific reasons have now been given in these pages for supposing that a discrete atomic theory of the ether is more accurate than the prevalent conception of a continuum which does not consist of discrete particles, and our new theory may be said to have completed Jeans's second stage of development ("Dynamical Theory of Gases," 1904, page 9)—"The true and false opinions are still equally in the field, but the former is supplied with weapons for defeating the latter."

FRED. G. EDWARDS.

33, St. Ronan's Road, Sheffield, January 29, 1917.

THE SOCIETY OF GLASS TECHNOLOGY.

THE January meeting of the above society was held at the Queen's Hotel, Leeds, on Thursday, the 18th ult. The president, Mr. W. F. J. Wood, B.Sc., took the chair at 5.30 p.m. The rules and constitution were passed, and it may be of value to intending members to quote the following:—

1. The society shall consist of—
   (*a*) Collective members, *i.e.*, firms who are engaged in the manufacture, distribution or use of glass.
   (*b*) Ordinary members, *i.e.*, persons (not being [illegible] representatives of collective members or students [illegible] bers) who are interested in glass technol[illegible]
   (*c*) Student members, *i.e.*, registered students who are attending a course or courses of technical instruction in the United Kingdom.
2. The annual subscriptions shall be as follow:—
   (*a*) Collective members, 3*l.* 3*s.*
   (*b*) Ordinary members, 1*l.* 1*s.*
   (*c*) Student members, 2*s.* 6*d.*
3. Application for membership should be sent at once to the Secretary, Society of Glass Technology, the University, Sheffield.

The election of Mr. B. B. Peacock as member of council, and Messrs. G. Wilson Clarke and F. Lax as auditors, completed the formal business of the meeting. Dr. P. G. H. Boswell, A.R.C.Sc., D.I.C., D.Sc., F.G.S., of London, then read a paper entitled:

"BRITISH GLASS SANDS: THEIR LOCATION AND CHARACTERISTICS."

The author began by stating that the analysis of British sands had proved their value. The analysis of sand can be carried out in three ways:—(1) Chemical, (2) mechanical, (3) mineral.

Chemical analysis proves the value of a sand by determining its silica content, which must be high, and its iron content, which must be low. In the past, sands with higher iron oxide content than 0.02 per cent. were regarded as useless for the best types of glass, but recent work has shown a higher iron content to be permissible, and so British sands can be used for good glass. Mechanical analysis determines the grading of the sand, the best for glass being that with the largest percentage of grains of diameter 0.25 to 0.5 mm. Mineral analysis is important in the laboratory for controlling consignments of sands, and also gives an indication of impurities to be expected.

Slides were shown to illustrate the microscopic appearance, chemical composition and grading of sands.

The relative value of crushed rock was discussed, and it was shown that after crushing, screening and washing were necessary to remove the larger grains and the fine material. By means of a geological map the position of English sand deposits and their situation relative to the centres of the glass industry was ably illustrated. The paper closed with a consideration of the transport question and the need for development of the canal system, together with a cheapening of railway rates.

Mr. C. J. Peddle, M.Sc., F.C.S., of Barnsley, followed with a paper entitled:

"BRITISH GLASS SANDS: THE SUBSTITUTION OF FOREIGN SANDS BY BRITISH SANDS FOR HIGH-GRADE GLASS-MAKING."

In the first place the author summarised the essentials of a good glass sand from the manufacturer's point of view, and showed that it must contain a high percentage of silica and a low percentage of impurity, particularly iron oxide. It must be evenly graded, and the grains should be angular. In addition, a sand should always be true to sample, and consignments should not vary, nor should there be any treatment necessary at the hands of the manufacturer. All these essentials are fulfilled by Fontainebleau sand, but not all by any British sand as at present supplied. That some British sands compare favourably with Fontainebleau, both as regards purity and grading, has been established by the author, whose results in general are in agreement with those of Dr. Boswell. In addition, a long series of melts also support this view, and on this account the statements of Dr. Rosenhain as to the non-availability of British sands for good glass are to be criticised. Splendid results are obtainable with British sands which have been properly treated, and numerous specimens of glasses made from British sands were exhibited side by side with the sands. Several of these glasses could not be distinguished from similar melts made with Fontainebleau sand, being just as brilliant and colourless. The question of treatment was then discussed, and the necessity for washing and grading was thoroughly demonstrated by a series of microphotographs, by chemical analysis, and by actual melts. The need of proper scientific treatment of British sands and the necessity of putting them into the manufacturer's hands ready for immediate use was emphasised, and it was pointed out that unless this treatment was forthcoming, together with attention to mode of delivery, British sands could not hope to compete favourably with Fontainebleau. Considerable discussion ensued.

Professor W. G. Fearnsides (Sheffield) advocated the co-operation of the glass manufacturer and the sand merchant, as the latter was not in a position to provide washing plant.

Mr. F. G. Foster (Birmingham) stated that the greatest difficulty before the sand merchant was to obtain an efficient washer at a low price. In addition, the amount of first-class sand required would not in many cases

repay the original outlay, and this, coupled with prohibitive railway rates, tended to stifle enterprise.

Mr. G. Dowse (London) pointed out that the demand for good sand was daily increasing and efforts were being made to place a better British sand on the market than had hitherto been obtainable.

Mr. J. McCormick (Scarborough) emphasised the fact that the steel manufacturer will give 15*s.* per ton for untreated sand, whereas the glass manufacturer expects to get it washed, graded and dry at 3*s.* The difficulty is not in designing a sand washer, but in making it pay.

Dr. Boswell said that too much must not be expected of the sand merchant, as the margin of profit was very small. A great advance would be to get railway freights lowered and water traffic taken up. Great improvements in British sands were observable of late, and the future was hopeful.

Mr. Peddle was of the opinion that the crux of the whole matter lay in a proper understanding of the glass manufacturers' wants. He felt sure that the British sand merchant could compete with the foreign sand merchant, both as regards quality and price, if the question were only tackled properly.

The next meeting of the society will be held in the University, Sheffield, on Thursday, February 15, at 4.30 p.m. Papers will be given on "The Annealing of Glass."

The United States Industry.—Speaking in New York, on December 21, Mr. Charles M. Schwab is reported, in the *Iron Trade Review*, Cleveland, Ohio, to have predicted that the United States producing 40,000,000 tons of steel to-day was as far from its zenith as it was in 1901, when its output was 12,000,000 tons. He added that though permanent peace would bring its adjustments to trade, this, in time, should prove a boon rather than a deterrent to prosperity. By way of practical suggestions to insure prosperity he proposed that measures be taken to encourage American shipbuilding and that American ships have lower tolls through the Panama Canal than foreign vessels. He predicted a great expansion of American shipbuilding if the Government rendered this industry due support.

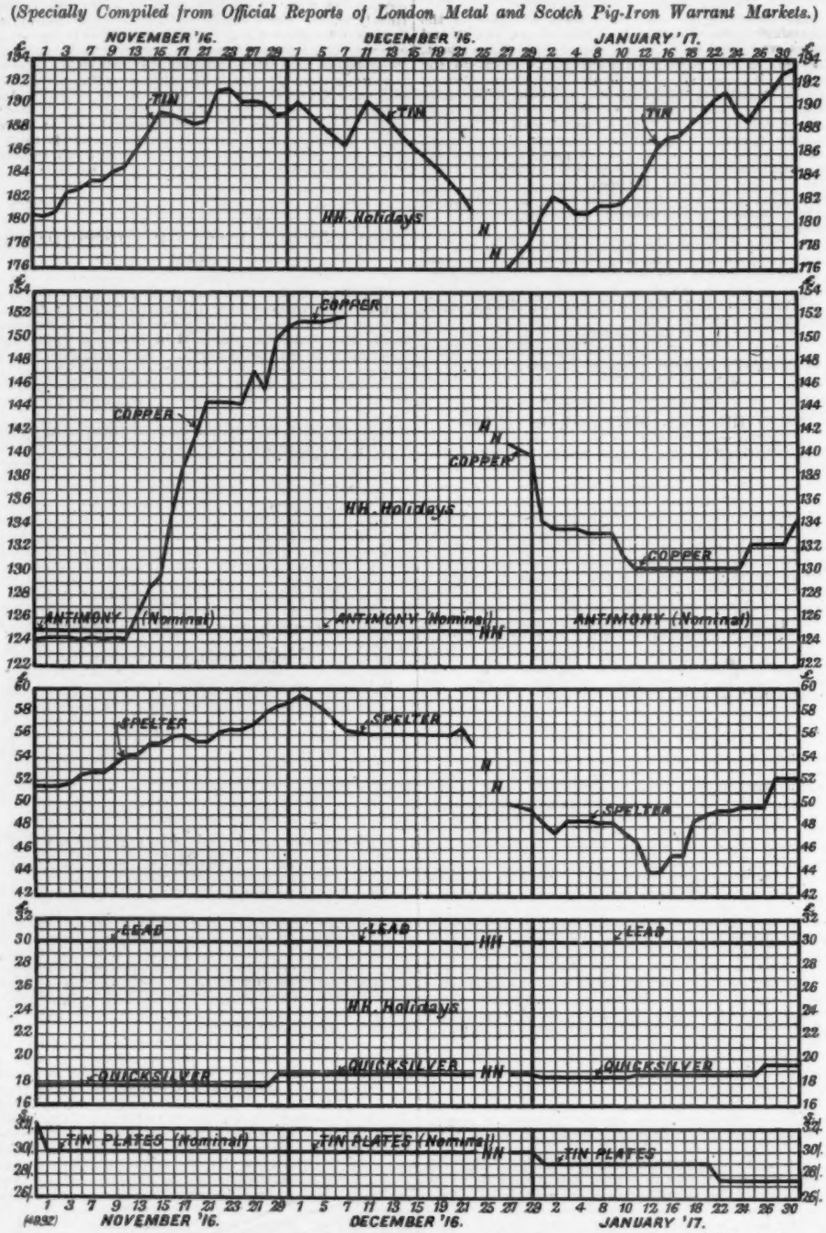
Austrian War Profits.—The Berndorfer Metal Works Company has during the third year of its existence as a company earned gross profits amounting to 22,940,490 kronen, or 450,221 kronen more than for the two preceding years together. Taxes absorbed 9,992,917 kronen, or 5,554,466 kroner more than for the two preceding years together. Writings-off amounted to 2,522,000 kronen and net profits to 10,425,570 kronen. The company only distributed about half the profits in dividends, the two classes of shareholders receiving respectively 17 and 16 per cent., against 21 and 20 per cent. respectively for the two preceding years together. The company's holdings of war loan and other stock have increased by 16,384,460 kronen during last year, at the end of which they amounted to 23,781,260 kronen. (1 krone = 10*d.*)

Type-Reading for the Blind.—At the meeting of the Röntgen Society on Tuesday next, February 6, Dr. Fournier d'Albe, physicist to the Board of Invention and Research, is to demonstrate his type-reading optophone by which blind persons are enabled to read ordinary letterpress by ear. This is done by audible telephone currents, produced by intermittent light of various musical frequencies. The printed sheet is passed over a slab with an aperture upon which a horizontal beam of light is projected from an illuminated siren disc, and by means of a set of selenium bridges exposed to light reflected from the type, sounds which vary with the shape of each letter are produced and carried through the telephone. The inventor states that the alphabet can be learned in three or four days, and with practice a speed of 25 or more words read per minute can be acquired. Dr. Fournier d'Albe also proposes to show other properties and applications of selenium, including its direct action in which one lamp is made to light another without relay. The meeting will be held in the Institute of Electrical Engineers on Tuesday next at 8.15 p.m. Visitors interested in the subject will be welcomed on this occasion.

Norwegian Shipbuilding Contracts.—The energy with which Norway is placing orders for fresh tonnage in almost every part of the world is attracting much attention. Many shipping concerns have been formed, and during 1916 large sums have been invested in shipping companies. Some 200,000 tons are stated to have been ordered, but no new craft of importance is expected to be ready before 1919, amongst other reasons on account of the serious shortage of raw materials. The Norwegian orders placed in the United States, which have been so freely commented upon, are estimated at a very substantial aggregate; a fair number of smaller vessels has also been ordered in Canada. Norwegian orders in Japan have been put at about 100,000 tons, and even China, it is stated, has received a share of Norwegian contracts. Holland is down for some 100,000 tons. The total of Norwegian orders for tonnage in the different countries is estimated at about 600,000 tons gross. At the same time several Norwegian shipowners seem desirous of disposing of some of their older boats, which, however, cannot be done as long as the present prohibition against selling Norwegian vessels to foreign countries remains in force. The shipowners, therefore, want Government to suspend this measure temporarily at least. It is urged that a deterioration in quality, through keeping inferior boats in the Norwegian merchant navy, would be even more undesirable than a reduction in quantity.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



Note.—In the diagrams above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for antimony and lead are for English metal in both cases, whilst those for spelter are for American metal. The prices are per ton, but in the case of quicksilver, however, the price is per bottle; the price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7 the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

The Railway Signal and Permanent-Way Engineer's Pocket-Book.—This pocket book is issued by the Locomotive Publishing Co., Limited, 3, Amen-corner, E.C., at the price of 2*s.* 6*d.* net, its object being to aid the engineer and practical man in dealing with everyday problems. It follows the development of fixed signals, gives the Board of Trade requirements in regard to signalling on railways, with a description of all the various types of signals used and their purpose, &c. A special section covers information in regard to permanent way and deals with the Board of Trade regulations, with rails and sleepers, their preparation, laying, wear, &c., and all other permanent-way component parts. The book is of a most handy size, it contains over 250 pages of subject-matter and clear illustrations, and is sure to meet with success.

Berlin Urban Traffic.—The total receipts in 1916 of the Berlin "Strassenbahn," jointly with the lines under its management, were 59,360,385 marks, against 52,203,966 marks in 1915; last year's receipts were the largest on record. The receipts of the Berlin "Strassenbahn" alone for the last years were: 1916, 47,781,139 marks; 1915, 42,053,367 marks; 1914, 40,893,855 marks; 1913, 44,483,065 marks; 1912, 44,127,195 marks. The company for electric high-level and underground lines also beat its previous records during 1916, the receipts being: 1916, 10,356,845 marks; 1915, 9,036,197 marks; 1914, 10,104,404 marks; 1913, 9,369,758 marks; 1912, 8,167,836 marks. On the other hand, the Berlin General Omnibus Company has suffered somewhat severely from the effects of the war, owing to the scarcity of horses and the stoppage of the motor traffic.

SCREW THREAD MEASUREMENT.*

By ARTHUR BROOKER.

SECTION I.—INTRODUCTION.

Of all mechanical contrivances, the screw thread affords the greatest convenience and the maximum of power in a given space and with a given weight, and consequently there is no more important or more widely used mechanical contrivance than the screw thread. Eighty or ninety years ago, when screws were used in small quantities, every maker settled the dimensions and form of thread for himself, and sometimes he went to the trouble of selecting measurements differing from those of other makers, in order that no other screw threads should be interchangeable with his own. Frequently the nut was made to fit its particular bolt, so that even parts made by the same manufacturer were not always interchangeable. Whitworth was the first to make an effort to remedy the resulting chaotic state of affairs, and after some years of experiment and study he published the result of his work in 1841, and suggested a standard form of thread, with a series of standard dimensions for bolts from ¼-in. diameter up to 6-in. diameter. The thread then suggested by Whitworth is known as the "Whitworth standard thread," and it has been widely adopted.

The form and dimensions of the Whitworth thread were not based on theoretical considerations, but were arrived at by obtaining the average of the threads then being made by the leading engineering firms, adjusting these average figures somewhat to simplify the standard figures, and submitting the results to experimental proof.

Whitworth's engineering work generally had a marked effect on British engineering practice, because he not only set higher standards, but provided the means for attaining thereto; and it is safe to say that, forty or fifty years ago, this country held the lead in the production of accurate work and apparatus for testing and measuring such work. Three years ago we had, except in a few very special cases, fallen to a comparatively low position; other countries, with the aid of some of our skilled workmen, had taken full advantage of Whitworth's work, and the conditions in those countries were such that their manufacturers had opportunities for turning out large quantities of repetition work, so that they could afford to provide special equipment and appliances, and could continually aim at improvement while continually making the same article; whereas in this country the reverse was the case, and the ordinary manufacturer rarely, if ever, had opportunities for producing large quantities of any one article. Only a few firms, highly specialised on account of the nature of their work, paid any attention to accurate measurements and interchangeability; and, as regards the general attitude towards the important question of screw threads, it is sufficient to recall the little attention evoked by the good work of the Engineering Standards Committee in fixing limits inside which screw threads must fall in order to be Whitworth threads. There were few machines in this country capable of cutting an accurate screw thread, and no apparatus available to the ordinary manufacturer for precisely measuring the result.

Of the measuring equipment now used in the average British workshop, about 90 per cent. is of American make, and nearly all the remainder of Continental make. It is painful to reflect that even the special apparatus about to be described could not be produced without the use of American-made micrometer heads. The conditions which caused or permitted such a fall from the first position surely deserve serious consideration, but cannot be dealt with in this paper.

In 1915, when the ordinary British manufacturer got his first chance of manufacturing in large quantities, and of working in conjunction with his brother manufacturers, instead of in intense competition with them, the want of knowledge as regards standards and the methods of producing interchangeable parts, particularly screw threads, quickly became evident. The manufacturer, aided by the skilled workman, seized the opportunity, and the manufacture of screw threads in this country is on a wonderfully improved footing now as compared with the early part of 1915, although much remains to be done.

Fig. 1 represents the profile of the screw thread of an actual gauge made by a firm of repute in the early part of 1915. This gauge was considered satisfactory, and was, in fact, well up to, if not in advance of, the current standard for gauges in this country; and no means were available commercially for indicating exactly where and to what extent it departed from the nominal dimensions.

Fig. 2 shows a similar gauge made in the same workshops 15 months later, and the improvement is evident; this second gauge is for all practical purposes perfect, yet it is now possible for the makers to say that it differs from the theoretical standard in one linear dimension by about one ten-thousandth of an inch, and that the angle differs from the correct angle by a fraction of a degree. The author believes, or at least hopes, that this particular case is fairly typical of the general progress that has been made.

When manufacturers, working together instead of in competition, were called upon to produce very large numbers of interchangeable parts, the need of the following became evident:—

1. The exact definition of standards and manufacturing limits to meet the new and abnormal conditions.
2. A more widely diffused knowledge of the principles of gauging and gauging limits.
3. Experience in the methods of producing accurate gauges.
4. Knowledge of the methods of accurately measuring and checking gauges.

The Whitworth form of thread was largely in use as the standard for the repetition work referred to, and the work of the Engineering Standards Committee on Whitworth screw threads and manufacturing limits for the same was immediately available, although not well known, and covering only a small portion of the field.

The dearth of knowledge on gauging, gauging limits, and especially the permissible limits on the gauges themselves, and the absence of apparatus for accurately measuring gauges, was a much more serious matter, and the fact that such good progress has been made in this difficult field is chiefly due to Dr. Glazebrook and his staff at the National Physical Laboratory. This Institution tackled the subject energetically and scientifically from the manufacturer's point of view and freely imparted information as it became available to those manufacturers interested. No measuring instruments were purchasable, but the National Physical Laboratory gave sufficient information to enable such instruments to be made, and this paper is intended, first, to describe measuring apparatus so made in Liverpool under the supervision of the author, for the measurement of screw threads, particularly the threads of gauges; and, secondly (as a result of experience gained in the use of that apparatus), to set forth certain of the methods and precautions that must be adopted to ensure highly accurate measurements.

Since Whitworth's day many other "standard" screw threads have arisen, and at least 28 of them may be considered as important from the extent to which they have been used, but in order to concentrate attention on the apparatus it will be advisable to confine ourselves to the consideration of one thread only, viz., the Whitworth Standard Thread, and to state clearly the accepted definitions of this thread. The sizes considered will be of about 2 in. diameter or less, since larger sizes are not made in millions, and do not, therefore, give rise to such difficult problems as regards interchangeability.

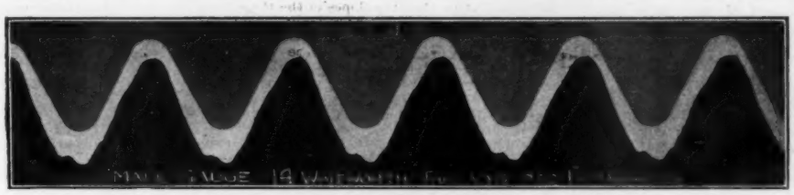


FIG. 1.

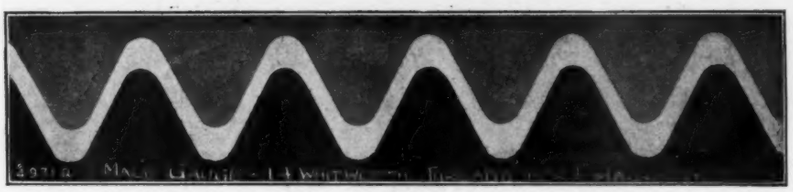


FIG. 2.

SECTION II.—DEFINITIONS.

Bearing in mind the necessity for maintaining standards even in terms, the definitions laid down by the Engineering Standards Committee will be followed. They are:—

Effective Diameter of a Screw.—The effective diameter of a screw having a single thread is the length of a line drawn through the axis and at right angles to it, measured between the points where the line cuts the slopes of the thread.

Core Diameter.—The core diameter is twice the minimum radius of a screw, measured at right angles to the axis.

Full Diameter.—The full diameter is twice the maximum radius of a screw, measured at right angles to the axis.

Crest.—The crest is the prominent part of the thread, whether of the male screw or of the female screw.

Root.—The root is the bottom of the groove of the thread, whether of the male screw or of the female screw.

Slope of Thread.—The slope of thread is the straight part of the thread which connects the crests and roots.

Angle of Thread.—The angle of the thread is the angle between the slopes, measured in the axial plane.

Groove.—The groove is the space between adjacent threads.

Pitch.—The pitch is the distance in inches measured along a line parallel to the axis of the screw between the point where it cuts any thread of the screw and the point at which it next meets the corresponding part of the same thread. The reciprocal of the pitch measures the number of turns per inch or millimetre, as the case may be.

NOTE.—From Figs. 3 and 4 it will be seen that the "core diameter" of the male thread is measured between the roots of the thread; it should be borne in mind, however, that the "core diameter" of the female thread, being approximately the same dimension, is measured between the crests of the thread. For graphical representation of the above definitions see Figs. 3 and 4.

Fig. 3. MALE SCREW; SECTION THROUGH AXIS.

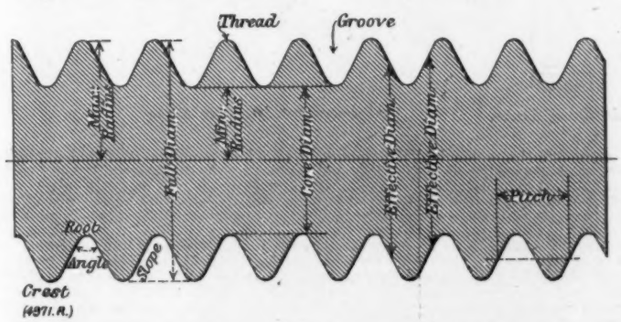
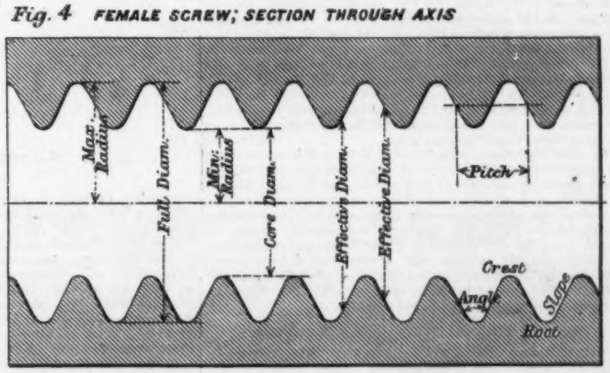


Fig. 4 FEMALE SCREW; SECTION THROUGH AXIS



* Paper read before the Liverpool Engineering Society.

Supplementary Definitions.

The above definitions are precise and are sufficient for ordinary purposes, but during a critical examination of screw threads and the making of exact measurements, particularly on gauges, various questions arise which are not settled by these definitions, and with the object of answering such questions, and perhaps stimulating discussion, the author suggests the following supplementary definitions :—

1. *Axis.*—The axis of a screw is the central line through the screw from which all corresponding parts of the thread are equidistant.

2. *Axial Plane.*—The axial plane of a screw is the longitudinal plane passing through the axis, that is to say, the axial plane contains but does not intersect the axis. There are, of course, an infinite number of axial planes, but one only is under consideration at a time, and its position is always well defined by the conditions.

3. *Normal Plane.*—The plane at right angles to the length of the screw, that is to say, the plane normal to the axis, may for convenience be called simply the normal plane.

4. *Screw.*—A screw consists of two parts—a cylinder whose diameter is the core diameter of the screw, and a thread which is a ridge of uniform section on the surface of the cylinder in the form of a helix.

5. *Zero and Infinite Pitch.*—The two limiting cases of a screw as regards pitch need consideration. When the pitch of the thread is zero it is convenient to assume that we obtain a cylinder with ridges in the form of parallel rings, and the "screw" in a fixed nut simply rotates without translation. When the pitch of the thread is infinitely great, we obtain a cylinder with a number of straight ridges parallel to the axis, and the result is no rotation, with infinite translation. (These definitions are open to discussion, but they are useful in practice.)

6. *Rake.*—The rake of a screw thread must be defined when measurements involving light rays are under consideration, and the following is a suggested definition :—

The rake of a thread is the amount of declination of the thread from a thread having zero pitch.

7. *Plane of Rake.*—The plane of rake of a screw thread is similar to the plane of rake of the corresponding helix. If from any point on a helix two straight lines are drawn, one the radius and the other a tangent showing the direction of the curve at that point, then the plane containing these two lines is the plane of rake.

8. *Angle of Rake.*—The angle between the plane of rake and the normal plane is the angle of rake. The tangent of this angle is always

$$\frac{\text{Pitch}}{\pi \times \text{full diameter}}$$ (See Fig. 5.)

9. *Slope.*—The slope of the thread (already clearly defined) is the most important feature of the thread. It is the portion which takes all the work, and all the other features are accessories for supporting it in position.

10. *Form of Thread.*—The form of a thread is the profile revealed by taking a section of the thread in the axial plane. It is most important to remember that the section must be taken in the axial plane, and not across the rake, as is sometimes assumed in the absence of any existing definition.

11. *The Effective Diameter* of a Whitworth screw may be measured as the length of a line drawn within the screw through the axis at any point, and at right angles to it, but on account of the fundamental importance of the slope it is, as a general rule, well to consider the measurement as taken between the middle points of the slopes. In a Whitworth thread these points, as well as other similar points, will always be diametrically opposite, but it should be remembered that this general statement is not universally true for all other forms of thread, for example, the Swiss thread.

Section III.—Methods of Measurement.

(1) Measurement of Elements by Microscope Micrometer.

No one instrument has been devised for measuring all the elements of a screw thread in the best possible way, but of the apparatus with which the author is acquainted, the microscope micrometer, as illustrated in Figs. 6 and 7, has proved to be the most useful for all-round work; and several measurements can be made with it better than with any other instrument. It has the great advantage that many defects can be actually seen on a large scale, and its introduction in any works is bound quickly to improve the accuracy in screw thread production, whether on gauges or on actual screwed work from the machines.

The instrument consists of a microscope mounted in a rigidly supported sleeve, and so arranged that the whole microscope tube can be rotated about its axis by hand. A circular scale divided into half-degrees, concentric with and firmly fixed to the microscope tube, serves to register the angle of rotation, and the half-degrees can be subdivided into minutes by a fixed vernier provided with a magnifying glass.

A single thread of spider's web (which will be referred to as the "web") is stretched across a diameter of a small ring, which fits tightly inside the microscope tube immediately next to the eyepiece and rotates with the whole system. The web is brought into sharp focus by moving the eyepiece in the tube nearer to or farther from it. The screw under examination is suitably mounted on centres in front of the microscope, and focusing adjustments must be such that a magnified image of the thread profile is produced on the microscope objective lens. The microscope can be rotated without altering the focus. The centres between which the screw under observation is fixed are mounted on a floating platform, which can be moved in two directions; the first along the axis of the screw, the second in a direction at right angles to the first, both movements taking place in a plane normal to the axis of the microscope. The magnitude of the movements in these two directions is controlled and registered by two micrometer heads calibrated in ten-thousandths of an inch and suitably fitted for these motions. The reading of the micrometers is greatly improved by fitting to the sleeves circular discs of brass, 3 in. diameter; this in effect extends the diameter of the sleeve and enables ten-thousandths to be engraved directly on the edge of the disc. It will be seen from the illustration that that the weight of the floating platform plus the screw in its centres is transmitted to the screw thread of the vertical micrometer head; this pressure is relieved by a counterbalance weight, another weight being used to keep the floating platform constantly in contact with the spindle of the horizontal micrometer.

The mounting of the microscope with its axis at right angles to that of the screw is not the only provision that must be made to ensure that the magnified image of the thread profile is the true profile in the axial plane, as defined above. It is equally important that the illumination must be produced by a beam of approximately parallel light rays shining over the crests of the threads, from the side of the screw remote from the microscope, up the microscope tube, and, further, the direction of these rays must be in the rake plane of the thread (see Fig. 8). Consideration of Fig. 9 will show that were the light beam, like the axis of the microscope, at right angles to the axis of the screw instead of along the rake, a certain amount of light would be reflected from one slope of each thread due to the angular relation between the slopes and the beam, and it is important to remember in setting up this apparatus that a similar effect will be obtained if the beam is not composed of fairly parallel light rays. This reflected light from the slopes of the threads has the effect of spoiling the definition of the image, and rendering accurate measurements impossible. The light source should be as small in area as possible, so that the rays may be condensed to a parallel beam by a plano-convex or other suitable lens. As the rake varies with pitch and diameter, the direction of the light beam must be under control and not fixed, in order that it may be adjusted to the rakes of different screws; this can be accomplished in one of two ways. First, the source of light may be outside the machine, as shown in Fig. 7, with the condensing lens mounted in a collimating tube at a distance from the point of illumination corresponding to the focal length of the lens; a practical dimension for this is 3 in. to 4 in. In this method the light beam passes through a hole in the side of the machine and is reflected up the microscope tube by a small mirror, which is swung in its sliding bearings until the light falls upon the tube and is, at the same time, in the plane of rake. This position is found by trial before commencing the measurement of each new screw, and in practice there is no doubt in the observer's mind when he has hit the correct angle, because only then is the definition of the profile of the image perfect.

The alternative method of illuminating referred to is that of mounting the source of illumination inside the machine, in the position occupied by the mirror in the first method. In this case the source must be completely enclosed but for the collimator, which will point towards the microscope tube, the condensing lens, as before, being mounted a sliding fit in the collimator. The source of light and the collimator must be capable of movement as a whole, and so mounted that the same facility as regards adjustment of the beam can be obtained as in the method employing the swinging mirror.

One further means of improving the definition of the profile of the image is essential, and that is a "light filter" composed of evenly-coloured glass, preferably green, which should be interposed in the beam in a position immediately next to the screw under examination on the side remote from the microscope. This filter has the effect of removing the slight spectrum rays apparent at some magnifications round the edge of the image.

With regard to the light source itself, a Nernst filament gives good results, and with its porcelain base is compact and handy for mounting. In default of the German Nernst, however, quite good results are obtained from the Ediswan "Pointolite" lamp, although this is larger to handle. Whatever the source of illumination, the candle power at the objective lens must not be too great, as this quickly tires the eye, and, in addition, leads to reflected light troubles. The source should be dimmed as required by trial observations. The facilities given by the rotary movement of the microscope, with the web as a measuring line, and by the two movements of the screw across the field, enable the elements to be measured as follows :—

Angle.—Fig. 10 shows the appearance of the field with the microscope set for the measurement of angle. The tube is rotated until the web coincides with one slope of the thread; a reading on the moving scale against the fixed zero is taken. The microscope is then rotated through the angle of the thread and takes up the new position as shown dotted, coinciding with the other slope; a second reading is taken. The difference between the two readings gives the thread angle at that position. Any transverse motion needed in adjusting the web to the slopes of the thread is given by the horizontal micrometer head without interfering with the angular measurement. Increased accuracy is obtained if the rotation of the microscope is always in the same direction, thus eliminating possible errors due to backlash.

Pitch.—Fig. 11 shows the web lined up with one slope of a thread. A reading is taken on the horizontal micrometer, and the latter is then screwed up, causing the image to move slowly across the field until the web coincides with the next similar slope; the setting of the microscope meanwhile again remains unchanged. A second reading is taken on the horizontal micrometer.

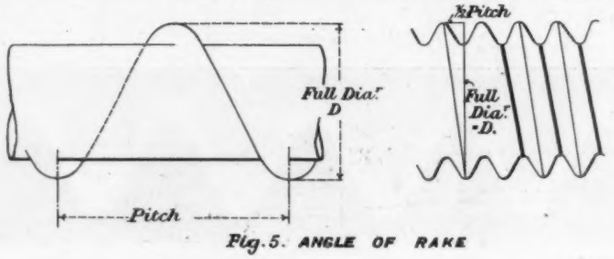
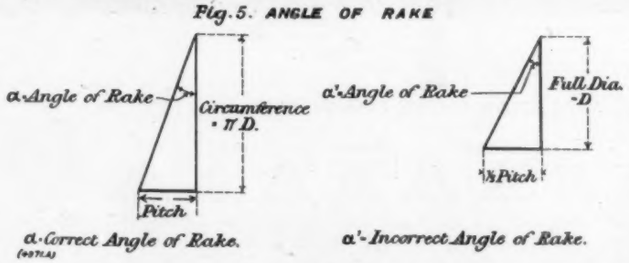


Fig. 5. ANGLE OF RAKE



α-Correct Angle of Rake. (NOTE A)

α'-Incorrect Angle of Rake.

The amount of travel of the screw, or, in other words, the "pitch," is given by the difference of the two readings. Similar measurements are repeated along the length of the screw to determine variations of pitch from point to point. In this measurement it is a good plan to take the whole series of readings before making the subtractions, as a foreknowledge of the dimension of the preceding pitch often biases the observer's mind in adjusting the micrometer when it comes to a choice between two positions differing by less than one ten-thousandth. In some of the illustrations the web does not quite pass through the centre of the field: this is, in many cases, rather an advantage than otherwise.

It is interesting to note that this method of determining pitch has an advantage over a point to point measurement, inasmuch as it gives a measurement between the whole length of slopes, not points, and the slope is the most important element of the thread.

Effective Diameter.—Fig. 12 shows the initial setting of the web to a slope in the determination of effective diameter. A reading having first been taken on the vertical micrometer, the latter is screwed up, causing the image to pass across the field in a direction at right angles to the screw's axis, until the bottom profile reaches and lines up with the web at a similar slope—Fig. 13. As before, the setting of the microscope remains unchanged. In this case the difference in the two vertical readings gives the travel of the screw, or, in other words, the effective diameter, and this method also has the advantage that it embraces the whole length of the slope of the thread. It will be remembered that because the direction of the rake of a screw thread changes with the progression of the helix, the direction of the rake of the threads on one side of a screw is angularly displaced to the direction of rake on the other side. Therefore, in the measurement just described, where the web is lined up with corresponding slopes on either side of the screw, the direction of the light beam must be altered before the second reading is taken.

The other Elements.—From the above it will be easily understood how by similar methods this apparatus can be used for the determination of core and full diameters, as also the depth of thread; the readings are taken on the vertical micrometer and the web is set in an horizontal position.

Having measured the angle, pitch and depth, the

SCREW THREAD MEASUREMENT.

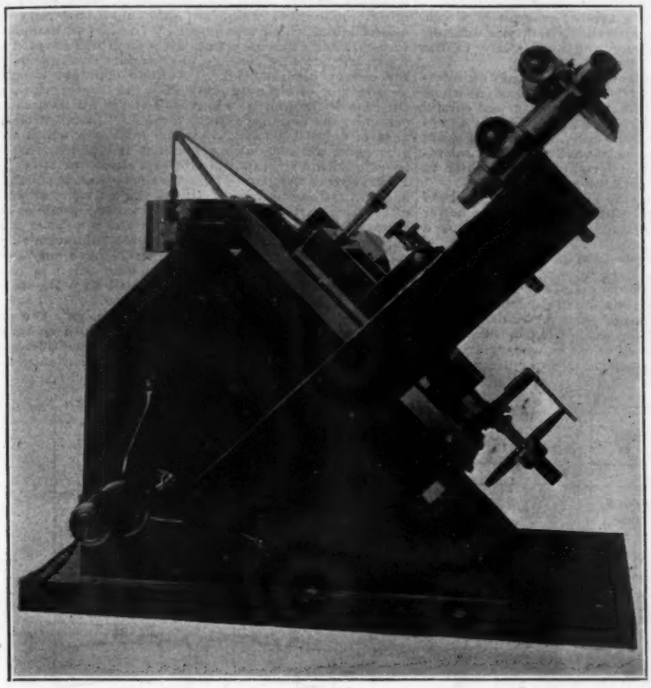


FIG. 6.

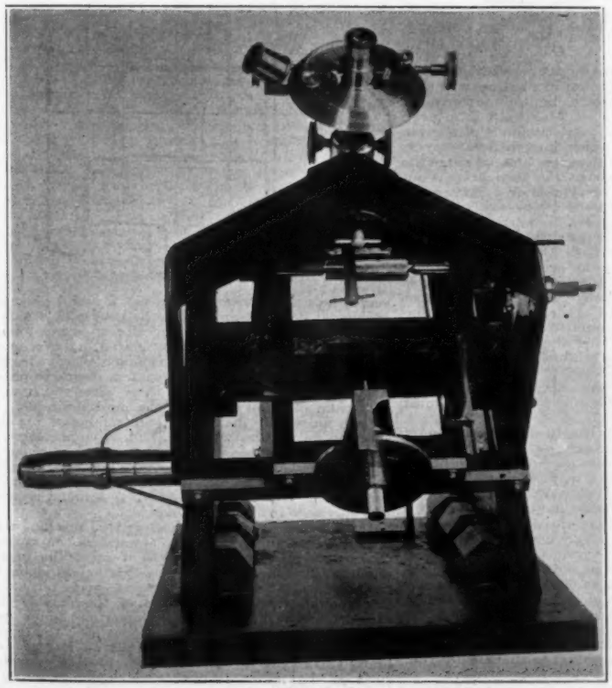
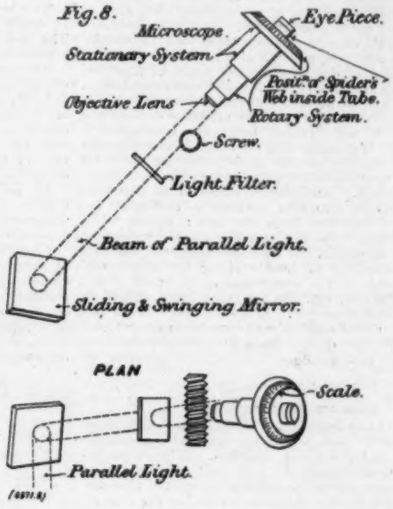
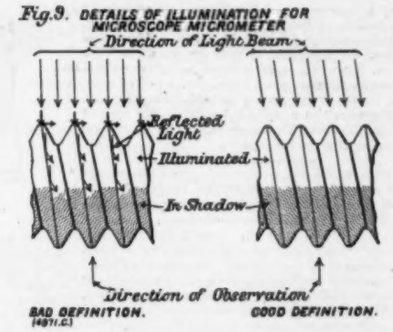
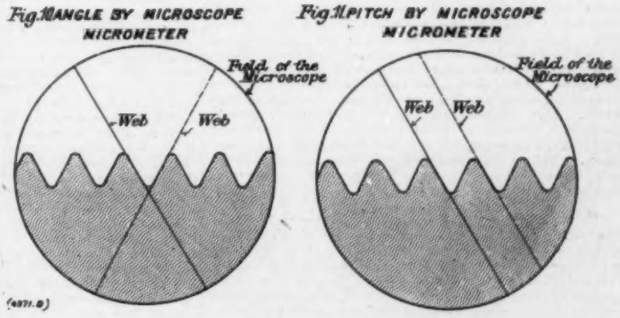
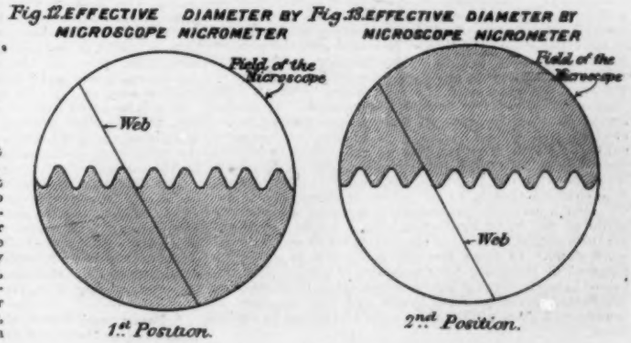


FIG. 7.









average radius at crest and root can be quickly calculated, but in practice it is far more important to know the exact form of curvature at root and crest, because a male screw gauge, otherwise correct in all the elements capable of actual measurement in the manner described, but with irregular curvature at crest or root, would bind when screwed into correct work, and thus reject it. A method of checking every mil of curvature at crest and root is described later.

In forming an opinion of the value and accuracy of the above apparatus, it is only fair to state that its use, as in the case of all optical instruments, is not entirely devoid of the personal error in observing. When this has been said, however, all that can be urged against the apparatus has been stated, while it is in favour of the machine to mention that those measurements which involve similar settings of the web to produce consecutive readings are largely free from this personal error, because, being repeated it disappears in the subtraction for the result. A good observer, after practice, will obtain

results true to one ten-thousandth of an inch and to within a quarter of a degree of angle or less. A large amount of information concerning the general outline of the thread is given by a general inspection of the image, which information is augmented by rotating the screw in its centres. This inspection reveals, amongst other things, the condition of the cutting tool, and its behaviour while cutting the thread. In cutting accurate threads of screw gauges a single-pointed tool is generally used, and the above apparatus also serves as the most accurate method of determining the angle of this tool during grinding and also before it is put into commission.

One or two specific instances of the deduction referred to above may prove useful; if the effective diameter is correct, and the core diameter large, the conclusion is that the tool has been shortened too much in rounding the nose, because the correctness of the effective diameter proves that it was fed sufficiently far into the work while cutting the thread. Similarly, a correct core diameter and large effective diameter indicate a tool with insufficient metal removed from the nose: hence, when the tool was fed into the work sufficiently far to produce a correct core diameter, the effective diameter was still over size. Variations of profile along the screw will indicate a change in the conditions of the tool or the work during the cut, *e.g.*, the tool may have shifted or the work become eccentric. Holes at the root of the thread point to minute particles of steel becoming welded to the nose of the tool during cutting; while excrescences show that the cutting edge has become chipped or flattened.

(To be continued.)

German Coal for Sweden.—The increased difficulties in obtaining coal from Germany continue to engross much public attention in Sweden. The German-Westphalian Coal Syndicate has sent a circular to Swedish importers of coal, in which it is stated that the serious reduction in the quantity available for export, resulting from the large home consumption, makes it necessary first and foremost to protect the interests of such consumers in Sweden to whom it is in the interest of Germany to deliver coal. As instances of such may be mentioned, firstly, railways engaged in the transport of ore, blast-furnaces, foundries, &c., and agricultural concerns, dairies, for instance, which do business with Germany. It is, however, questionable to what extent the requirements as regards coal, coke, &c., even of such consumers can be satisfied, seeing how far the German demand has outgrown the available supply. By way of an experiment public Swedish interests will be placed on the same footing as the German ones.

House Building in China.—According to a statement in *The London and China Telegraph* the native houses in China are all frame. The uprights are usually native round fir poles, 6 to 8 in. in diameter at the base. Divisions between houses are of 3-in. brick. Joists carrying the floor and roof are round fir poles. The flooring is pine, lap-jointed or tongued-and-grooved. Doors are of pine, made up of thin boards nailed to a frame. Windows are glazed with fourth-quality glass. No hardware is used. Ironwork entering into the construction consists only of rainpipes from the roof and nails for the flooring. The walls of foreign residences, shops, &c., are generally of solid brick; fronts are sometimes constructed of granite, stone, or artificial stone. Timber is invariably Oregon pine; floors are of Oregon pine or Singapore redwood. This latter wood is also extensively used for cabinet work. A good quality of lock sets is used, generally of British manufacture. The use of reinforced concrete has grown rapidly, and it is now being extensively employed. Expanded metal, wire-mesh and reinforcement bars of every description are in great demand, although at high prices. The demand will, in all probability, greatly increase. Cement is being consumed in increasing quantities, the demand being met from mills in or near China. Before the war Belgium was practically the only source of supply for window glass; now it is obtained from Japan and America.

Testing Artificial Limbs. The Magnet Hand.—The testing of artificial limbs, especially such as would enable men to do mechanical work, was taken up early in the war by the Verein Deutscher Ingenieure, and in February, 1916, a special testing station for these appliances was opened in Charlottenburg. Illustrated descriptions of various apparatus have appeared in the Journal of the Verein. Among these we notice the magnet hand (not patented) of Professor Klingenberg. In this device the attachment to the arm or shoulder ends in a cup which encloses an electro-magnet; the cup is fitted with a ball bearing and can be clamped in any position; the electric circuit is closed or opened by the aid of the other arm or the chin. It is said that the magnet hand helps a man to do filing and planing, to put metal sheets under a punch, and even to manipulate shears or pincers; tools not of iron are provided with an iron ring or plate, so as to become manageable. It is also suggested that the magnet hand might attend to an electric switchboard; the introduction of magnets sufficiently strong for mechanical pull might there and elsewhere lead to unpleasant magnetic effects, however, we should think. The hand can also be provided with fingers and a thumb, to be opened or closed separately. Of other apparatus, praiseworthy mention is especially made of the American Carnes arm. Limbs submitted for tests should enable the man to do six or seven hours' work daily. In tests recently performed at a marine hospital in Hamburg very satisfactory results were obtained in workshops for instrument-making, with ordinary labourers, formerly dock hands and men engaged in cement and glass works, and not at all trained to skilled work.

WORM GEAR AND WORM GEAR MOUNTING.*

By F. W. Lanchester, M.Inst.C.E.

(Concluded from page 92.)

APPENDIX.

The worm assemblage is a typical example of a case in which to obtain perfect interchangeability is difficult. The designer needs to make a careful study of the conditions.

The production of manufactured articles on an interchangeable basis is a modern development, and the whole subject, perhaps, has not had the systematic and careful study from the designer that is its due; there is a tendency to regard the interchangeability as something apart from the design proper, and to leave the whole consideration of the subject to be undertaken subsequently to design in the tool and jig department.

In the present Appendix the author is giving a brief outline of the system adopted in 1900 by the Lanchester Company, the worm gear mounting being taken as a typical illustration.

Firstly, a few words may be said on the broad theory of interchangeable components in mechanism. Interchangeability depends fundamentally on the power of measurement. The appliances at the disposal of the engineer for the measurement of parts prescribe the limit of accuracy from a stated dimension that can be recognised, and accuracy in manufacture can never equal or transcend the power of measurement. Interchangeability

Fig. 33.

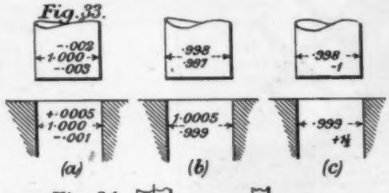
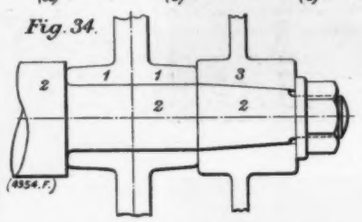


Fig. 34.



is only possible so long as the limits permissible to the individual components on account of the functions they have to perform is greater than the limit of measurement available; for example, if a shaft to work in a given journal must be within 0.001 plus or minus of a given size, it is only possible to secure interchangeability so far as the shaft is concerned if we are able to gauge the part with certainty within 0.001. But the matter is not quite so simple as this; in every case of working parts or fitting parts in a machine there are at least two parts which may be said to form a "mechanical circuit": thus in a shaft bearing there is the shaft and the journal. Assuming the latter to be a bush, the essence of interchangeability is that the difference between the maximum permissible clearance and the minimum permissible clearance must be divided between the shaft tolerance and the bush tolerance. In other words, if the diametrical clearance may be permitted to vary by 0.002, and the shaft tolerance be fixed at 0.002, the accuracy of the bush would require to be absolute, and *vice versa*. Giving an equal tolerance to each of the components of the circuit, namely, 0.001, the diameter of the shaft, and equally the diameter of the bore of the bush, must be gauged within this limit.

It is important to have a perfectly clear conception of the difference between the meanings of the words clearance and tolerance. The clearance between two fitting parts is the absolute difference in their dimension, and the range of variation in the clearance is due to the combined magnitude of the individual tolerances.

It is the custom in some factories to assign a "parent" dimension on any part, and to give a tolerance plus and minus. In other factories the system has been adopted of writing in full the maximum and minimum dimensions. The author's system, as used at the Lanchester factory, is to write either the minimum or the maximum as the parent dimension, with an index beneath either plus or minus as the case may be, one-thousandth of an inch being taken as the unit. The three systems of dimensioning are given with respect to a nominally 1-in. shaft bearing in Figs. 33, *b*, *a*, and *c* respectively.

It will be noted that according to the author's system, Fig. 33*c*, the shaft bearing is figured with its maximum dimension and the tolerance with a minus sign, whereas the bush is figured as a minimum dimension, as shown by the tolerance having a plus sign.

The difference in these various methods of dimensioning might be regarded as merely a matter of notation or convention, but the author cannot but feel that there is more in it. His own conception of the problem of interchangeability is as follows:—If it were possible to make each part with perfect accuracy to a specified size or dimension, the clearance which would be assigned in the dimensioning of any two working parts would be the least clearance at which they would work satisfactorily; then, in the course of the life of the machine, the clearance would gradually increase until it reached some maximum value at which replacement becomes necessary. Now the author has always taken the view that the tolerance on the component should be regarded as an initial amount of wear, an unfortunate necessity or imperfection, which is imposed by the fact of manufacture. It is on this basis that the system was adopted in which the parent dimension of each part corresponds to the closest permissible fit. Nothing could be simpler as a matter of clear thinking than this basis; thus, in the case of the journal which we have so far used as an example, the designer says to himself, "I want a clearance of (say) 0.002 in.; it is the minimum which will give good working, also experience has shown that a bearing with a clearance of 0.008 in. should be replaced. I will allow as the greater limit for the clearance 0.004 in., and will assign 0.001 in. of this to the tolerance of each of the two parts." In this case it would be fair as an approximate statement to say that the purchaser who happens to get a maximum bush and a minimum shaft together in the machine he buys, would have only two-thirds the life that would be the case where a man purchases a machine in which the particular parts are at the limits given by the parent dimensions.

It may be claimed, in favour of the author's system, that the method of dimensioning a part with an intermediate dimension and a plus and minus tolerance (Fig. 33*a*), is inferior, inasmuch as the dimension given

Fig. 35.

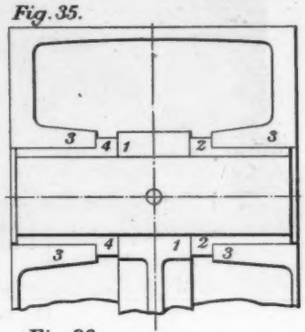
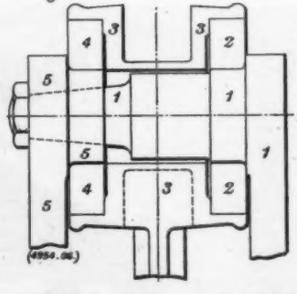


Fig. 36.



serves no useful purpose; it is not a useful dimension, because it does not appear on the gauges by which the part is rejected or accepted at all; it is not an ideal dimension, because, as before stated, it presupposes that a certain initial wear has taken place: in other words, if two parts giving the smallest clearance possible by the limits will work, then these parts will have the maximum durability and are the most desirable. The system in which maximum and minimum are both specified on the drawing (Fig. 33*b*), is cumbersome. It means a considerable addition to the amount of figuring to be inserted on the drawing, it does not give at a glance the degree of accuracy of the part required, and means considerable scratching out, &c., if it is found necessary by experience to alter clearances.

In producing an experimental or trial machine which it is intended subsequently to standardise on an interchangeable manufacturing basis, it is of the greatest possible advantage to start by specifying clearances and tolerances, just as if the machine were being put at once into manufacture. The success of the manufactured article depends in some degree upon the limits being properly assigned, and the trial machine, whatever it may be, should be used incidentally to test proposed limits and secure information. For bearing or wearing surfaces the minimum clearances should be aimed at, and then where parts have to be eased in order to obtain good working results the subsequent gauging of these parts will tell the designer what his minimum clearance (as determined by the parent dimensions) ought to be.

It is often convenient to put a trial machine in hand from drawings which have not been fully detailed, and to have the components made from drawings of group assemblages; it is one of the advantages of the author's system of tolerance notation that dimensions may be inserted on an assemblage drawing, and the sign of the tolerance shows clearly to which part the dimensions relate. This also is a great convenience to the designer in other cases, inasmuch as he may prepare an assemblage drawing and fill in any dimension which he deems to be of capital importance without the draughtsman who subsequently prepares the details being in any doubt

* Paper read before the Institution of Automobile Engineers on December 13, 1916, slightly abbreviated.

as to whether a given dimension relates to the inner or outer part.

In the elementary example it has been assumed that the total tolerance, that is to say, the permissible clearance difference, is divided equally between the two controlling tolerances; this, however, is obviously not necessary, it is a matter where the experience and judgment of the designer will come in, as to whether a greater tolerance should be given to the one part or the other—it will depend largely upon whether it is easier to get accuracy in the manufacture of the one or the other component.

It has been stated that the foregoing example represents the simplest possible case of a "mechanical circuit," being one in which there are only two parts. In the design of any actual machine there may be three or four or any number of parts, and it is here that the conception of a mechanical circuit becomes of value. In Fig. 34 an example is given of a three-part circuit, in Fig. 35 we have a four-part circuit, in Fig. 36 a five-part circuit. It is clear that the greater the number of parts in the mechanical circuit, the greater will be the accumulated effect of the tolerance (allowed to the individual parts

Fig. 37.

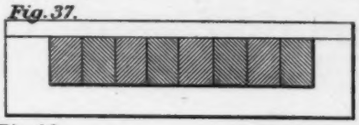
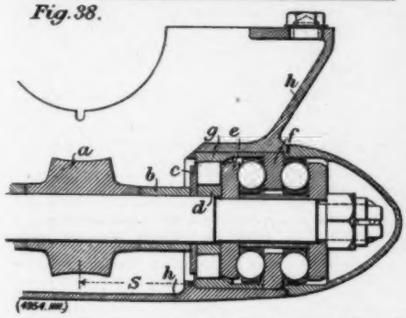


Fig. 38.



in manufacture) on the ultimate clearance value. In some cases, as where there is a clearance between every part, with its oil film, such as a number of sliding bars housed parallel to one another between two retaining jaws, Fig. 37, no actual accumulation of the individual tolerances is liable to take place, since the oil film may be said to exercise a certain pressure which is a function of its thinness, and automatically the clearance will be divided; in cases, however, where a number of the components are brought into forcible contact the sum of the tolerances may appear at, or be concentrated on, some particular clearance dimension, and in this case the difficulties of interchangeability are greatly increased; it must be the designer's object to avoid trouble by reducing the number of parts in the "mechanical circuit" to the minimum. Such a case is typically illustrated in a worm gear mounting shown in Fig. 38; in this case there are no less than eight parts in the mechanical circuit, and there is only one clearance dimension. The eight parts are labelled *a*, *b*, *c*, *d*, *e*, *f*, *g* and *h*, and the dimension in which the clearance is felt may be regarded as that given by the letter S. This dimension S is affected by the accumulated tolerance of the eight parts *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*. Under these conditions the permissible variations in S, divided by the number of components in the circuit, defines the degree of accuracy of manufacture or tolerance necessary for the individual components. It is clear, therefore, that if the accuracy necessary in the dimension S is greater than can be divided by the number *n* (8 in the case in point) without resulting in an impracticable close limit from a manufacturing standpoint, full interchangeability may have to be abandoned. It is for the designer to avoid, so far as possible, permitting accumulations of this kind, and the worm wheel mounting, whether as to wheel or worm, requires due study from this point of view.

More broadly, in any design whatever which is being prepared for interchangeable manufacture the number of parts in every "mechanical circuit" should be kept as low as possible; that is to say, where there are two possible alternative schemes, the one which presents the simplest mechanical circuits will, other things being equal, be the most desirable from the manufacturing standpoint.

In dealing with complicated cases it is desirable to have a ready means of checking the resultant tolerances of any given aggregate of components whose individual tolerances have been or are being specified. In the design of the 10–12 Lanchester car in 1889 this problem occurred so often that the author issued a standard procedure entitled "The Arithmetic of Tolerances" in order to assist his drawing office staff in figuring these cases. The rules laid down refer more particularly to his own system of tolerance notation; they are as follow:—

General.

1. Whether adding or subtracting, add tolerances irrespective of sign to obtain new tolerances.

Addition.

2. With tolerances of the same sign add the quantities, add the tolerance and preserve the sign.

3. With tolerances of different sign add the quantities and add the tolerances (irrespective of sign), and after assuming a sign for the sum tolerance, which may be either plus or minus at discretion, embody* in the sum of the quantities the tolerance that has a different sign to the sign assumed for the tolerance of the sum.

Examples.

4. When there are more than two quantities to be added, add separately all those with tolerances of plus, and those of minus sign, and add the two quantities so obtained (Rule 3).

Subtraction.

5. With tolerances of different sign subtract as usual, and give the tolerance of the remainder the same sign as the tolerance of the whole.

Examples.

6. With tolerances of the same sign,

(*a*) If we give the tolerance of the remainder the same sign as in the quantities, we must embody* in the remainder a tolerance of equal value, but of opposite sign to that of the subtractor.

Examples.

(*b*) If we give the tolerance of the remainder the reverse sign to that in the quantities, we must embody* in the remainder a tolerance equal to, and of the same sign as, that of the whole quantity.

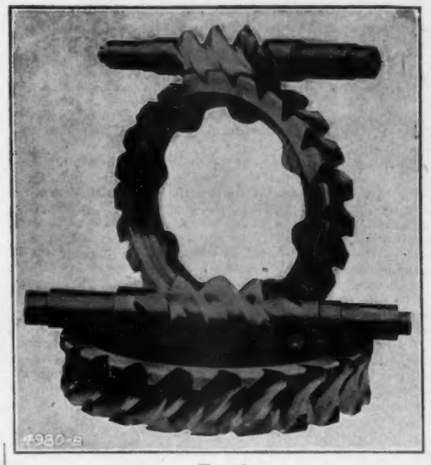


FIG. 1.

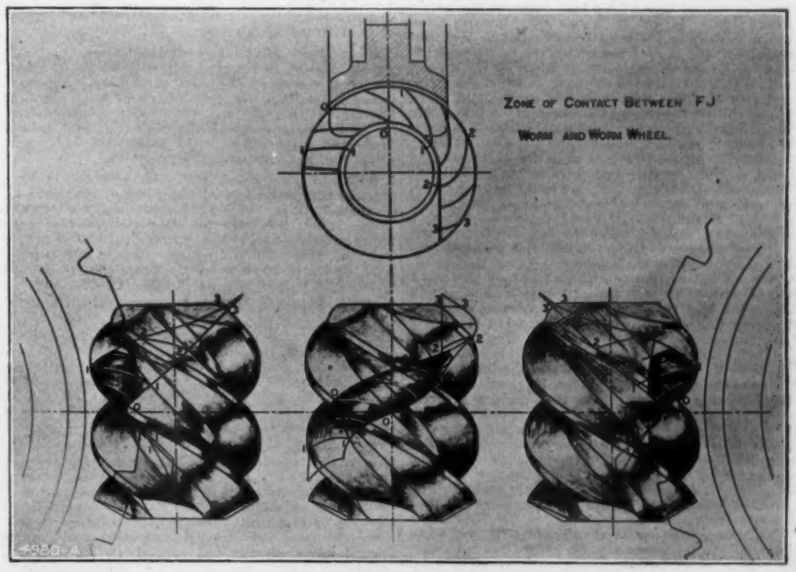


FIG. 2.

We have been requested to publish the following report of the speech made by Mr. Francis J. Bostock in the discussion following the reading of the above paper.

"I have been greatly interested in Mr. Lanchester's paper on 'Worm Gear and Worm Gear Mounting';

* As the algebraic sum.

he has again introduced quite a lot of matter which should form a good basis for discussion. As, however, I have been personally referred to by the author in my association with Messrs. David Brown and Sons, I think it will be better for me to confine my remarks to the theoretical aspect, and leave to other members the discussion respecting the methods of mounting, &c.

"The author has certainly been to a considerable amount of trouble in order to investigate the form of contact between the teeth of the worm and the wheel, and thereby endeavour to show that it is superior to the parallel type, with which, of course, I cannot agree. One could almost judge from his remarks that the Lanchester or hollow gear should be in absolutely universal use, and the last word in worm gearing, also that the D.B.S., or parallel type, is obsolete, but the fact remains that the latter is being manufactured and employed in ever-increasing quantities both in this country and the U.S.A. On account of several important points having been overlooked, which certainly appear to indicate considerable misapprehension as to some of the fundamental facts connected with worm transmission design,' I wish to take this opportunity of pointing out one or two great fundamental differences between the two systems.

"The idea of taking a number of sections of the teeth in engagement is not new; I have already employed it for similar investigational purposes. The results, unfortunately, were not quite the same as those obtained by the author of the paper, possibly due to the fact that I was compelled to take a hollow face worm which appeared to contain some distortion due to hardening and inaccuracies brought about by buffing. These defects are, I believe, inseparable from the Lanchester system on account of the inability to precision grind the worm threads after hardening. The author does not say that he took for his investigation a worm under these conditions; one can assume that his 8 by 33 gear had not been hardened, and so was hardly a criterion of the finished product. On the other hand, however, the D.B.S. worm, which had been hardened and ground, was afterwards subjected to heat-treatment for the purpose of sawing up. Thus at the outset one sees that with the hollow worm the errors consequent to a hardening operation had been avoided, whilst with the parallel worm the errors and distortion due to heat-treatment had been introduced; thus it had been deprived of one of its most valuable characteristics. I do not wish unduly to emphasise this, but it is an important feature of the D.B.S. gear.

"A further point, which is likely to escape notice, is that the comparison was made between two entirely dissimilar sets of gears, *i.e.*, 5 by 21 D.B.S. against 8 by 33 Lanchester, and naturally there is greater contiguity of contact where the respective numbers of teeth are higher. The photographs fail to inform one that the Lanchester gear, being for a considerably greater centre distance, is not only larger in diameter, but it has a pitch of less than two-thirds of that of the other. Again, Fig. 11*a*, page 45 *ante*, indicates that the Lanchester wheel had a considerably lesser face width than the D.B.S. wheel. I think it will be agreed that the above considerations will show that the comparison has not been made upon equal terms, which unfortunately removes from the investigation a very large amount of its intrinsic value.

"Mr. Lanchester himself seems to be disappointed with the photographs. I agree. They do not give a clear impression; they are not at all conclusive nor

convincing. To my mind his method of taking sections is insufficient, and liable to give totally erroneous results. The true conception can only be obtained by taking series and series of such sections in order to embody the rotation of the worm. The worms in the photographs have remained fixed, and as dead worms instead of live ones have been investigated, I propose to emphasise the difference between the two types when they are in action.

"The remarks upon the photographs and the diagrams (Figs. 11*a*, *b* and *c*, page 45 *ante*) are, I think, intended to imply that there exists practically full contact from the moment the worm thread enters the wheel until it leaves. The author speaks of the rubbing surfaces, their differences in curvature, &c., but says nothing about the teeth rolling upon each other; in fact he seems to have fallen into the common error of assuming that practically the whole of the tooth action in worm gear is that of rubbing or sliding. Quoting from his paper, he says, 'It will be noted that over the engagement portion of the surfaces the thickness of the matrix interspace is nowhere more than a fraction of a millimetre'; hence if the teeth of his worm fit in the manner indicated they cannot roll upon each other during engagement, and the rubbing velocity between the worm and wheel teeth must therefore be substantially equal to that of the pitch line along the thread, which can be easily calculated. In fact Mr. Lanchester told us in his previous paper, Proc. I.A.E., vol. vii, page 279, that 'The line (of contact) sweeps the tooth of the worm wheel from end to end twice, that is, one complete return journey during each engagement'; thus the contact is on the same side of the wheel at the finish as it was at the commencement of the engagement, therefore giving the rubbing effect its maximum value. With the D.B.S. gear, however, the conditions are entirely different.

"If one considers the action of spur gear teeth one finds that the resultant motion is a combination of rolling and sliding, the former causes the push, as it were, whilst the latter causes the friction. To reduce the amount of sliding action to a minimum is one of the special considerations of spur gear design, which, of course, applies to a far greater extent to worm gear. The aim should therefore be to obtain the maximum rolling or pushing, and so reduce the amount of rubbing the greatest possible extent. Worm gear should be designed so that the power is transmitted not by sliding alone, but by rolling.

"In order to illustrate the above remarks, a diagram has been prepared illustrating the tooth action of the D.B.S. gear, typified in Fig. 1, which shows two pairs of 9-in. centre gears of 3 : 22 ratio. Fig. 2 shows four views of a similar D.B.S. worm and wheel of 4 : 25 ratio designed on the same lines as the one investigated by Mr. Lanchester. The ribbon-like area stretching across the teeth is the mathematical zone of contact between the gears. The intersection of the worm thread and this zone gives the line of contact between the worm and wheel teeth. It will be noted that the full theoretical contact is possible over practically 225 deg., but the actual amount is determined by the width and the diameter of the wheel, as clearly set forth by the shaded portion. The zone shown is the contact when the worm is rotated in the direction indicated in the end view, wherein it will be observed that the contact line starts on the entering side of the wheel face, where it is practically straight, radial and parallel to the wheel axis; it then travels across the face with its outer portion gradually lagging behind, and finishes tangentially to the bottom of the tooth, so that one could have a wheel throat or face enveloping almost three-quarters of the circle of the worm. The top end view also shows a series of intersections for every 45 deg. rotation of the worm; the alternate lines, giving the intersections which correspond to 90 deg. movements of the worm, or—as we are considering one which has four threads—the line of contact on each thread. Incidentally, it will be seen that had this been an eight-threaded worm, simultaneous line contact would have existed on no less than five threads.

"Following the direction of rotation, it will be noted that if the contact for one thread be on the line marked '0,' the next thread will have contact on the line marked '1,' the following '2,' &c. Now the distance between '0' and '1' corresponds to one thread, and is therefore equal to a 90 deg. rotation of the worm, but when this movement takes place the actual contact also travels in the same direction as the worm through a distance of approximately 50 to 60 deg; hence about two-thirds of the motion is transmitted by a rolling action. The real rubbing velocity is only about one-third of that usually calculated, and which obtains in the Lanchester gear. This means that instead of having the gear teeth rubbing against each other say, at 1,000 ft. per minute, rolling action is so introduced that the real rubbing velocity is reduced to about 350 ft. per minute. Mr. Lanchester has been at great pains to show the contact he obtains, and in doing so has, I think, failed to note, to the disadvantage of his gear, this strikingly interesting and important feature of the D.B.S. gear.

"Now it is generally supposed that in worm gear the pressure multiplied by the velocity is practically constant. Although I do not think this is quite correct, it is sufficient to show that by reducing the rubbing velocity in the manner already explained the permissible pressure between the teeth in contact can be very considerably increased. It is of far greater importance to have rolling action and low surface sliding than to have the high rubbing velocity with a corresponding reduction in the permissible pressure.

"The above facts conclusively demonstrate the theoretical advantage of the D.B.S. type, and also indicate that as the amount of sliding is less, the distance through which its load has to be moved is less, thereby tending to give a higher theoretical efficiency. Again, there is no question about this reasoning entirely explaining Mr. H. Kerr Thomas's observations respecting the high efficiency and load-carrying capacity of the parallel gear.

"The sum total of Mr. Lanchester's investigation is that, although he has not succeeded in 'clearing up these points of controversy,' he has clearly shown what I consider to be one of the serious inherent defects of his system of worm gear. The argument why the Lanchester type should carry more load, centre for centre, than any parallel type has not been proved, being based upon an incomplete hypothesis; it is unsound, having apparently been brought forth without full knowledge of the case.

"If, however, Mr. Lanchester be really desirous of demonstrating the difference between his type and the D.B.S. as regards load-carrying capacity, efficiency and probable life, and he will come forward at some convenient time after the war, I, on behalf of Messrs. David Brown and Sons, will be quite agreeable, being in fact anxious to assist him. With this end in view I shall be willing to test the particular gear I am interested in against his under the following headings:—

"1. For load-carrying capacity. Comparative curves of temperature rises for different loads and speeds to be obtained.

"2. For efficiency at various loads and speeds. These tests to be run, at any rate, for several hours.

"3. Any other test Mr. Lanchester wishes.

"4. To destruction. This is to be accomplished in approximately one week's run, and the rate of wear at various portions of the worm and wheel faces to be observed.

"The only stipulations I make are that the conditions shall be identical in both cases; in the first series of tests Mr. Lanchester shall for the purpose of a true comparison being made fix the sizes of gears, my gears to be made the same as his as regards centre distance, number of threads and teeth and approximate diameters; and in the second series of tests Mr. Lanchester shall furnish gears made to sizes selected by me. All other dimensions, such as length of worm, width of wheel, &c., to be left to our respective discretions, but no radical departure to be made from the standard practices employed by each firm.

"In conclusion, I am sorry I cannot enter into further discussion at the moment, as my time is more than fully occupied with important war work, otherwise I should have had great pleasure in dealing with other points raised in the paper."

CATALOGUES.

Gas Engines.—The Chicago Pneumatic Tool Company, of Fisher Building, Chicago, U.S.A., have sent us three separate bulletins dealing with gas engines, railway motor cars and electric drills. The gas engines are of the two-stroke cycle type, and are made, with single cylinders, of from 16 up to 110 h.p.

Second-hand Machinery.—Messrs. Thos. W. Ward, of Albion Works, Sheffield, have sent us their quarterly list of new and second-hand machinery. As usual, it includes almost every conceivable kind of plant, from locomotives to desk fans, turbines, machine tools, contractors' gear, boilers—both water-tube and internally fired—and an assortment of materials, such as rails, scrap iron, pig and structural steelwork.

Lubricant Pumps.—A pamphlet sent to us by The Cincinnati Lubricant Pump Company, of 126 Opera-place, Cincinnati, Ohio, U.S.A., urges the merits of employing a copious flow of lubricant to the cutting edges of machine tools, and puts forward, as the best means of providing this flow, the "Fulflo" pump. It is of the centrifugal type, and is claimed to have none of the disadvantages of the gear pump, such as clogging and wearing.

Water Softeners.—"The Paterson 'Red Book'" is advertised by a leaflet which we have recently received from The Paterson Engineering Company, Limited, of Windsor House, Kingsway, London. The "Red Book" is intended to give a short *résumé* of the impurities found in natural water supplies, and the modern methods employed to render water suitable for all industrial purposes, while, of course, advocating the Paterson type of apparatus for the purpose.

Lathes.—Messrs. Haigh's (Oldham), Limited, of Globe Iron Works, Oldham, have recently issued a new priced catalogue of machine tools. These are principally lathes, and many of them are specially designed for the production of shells up to 12 in. in diameter. The machines are substantially built and proportioned to carry the heavy stresses of high-speed roughing cuts. Special collet chucks and stays have been added to some of the lathes to facilitate finishing operations on projectiles.

Anti-corrosive Paint.—A publication recently issued by Messrs. D. Anderson and Son, Limited, of Roach Road Works, Old Ford, London, E., takes the form of reproductions from photographs of steel plating in various stages of rusting and demonstrates the value of "Siderosthen" as a protective. It is claimed that this material will work its way right through scale and rust to the metal itself, and thus prevent further corrosion. It has been tried in all sorts of climates and atmospheres, and has proved very effective.

Timber.—From the Agent-General for British Columbia 1-3, Regent-street, London, S.W., we have received a bulletin concerning Douglas fir as a structural material. It is stated that there is a total stand of four hundred billion feet of commercial-size timber in British Columbia, and that the average annual cut is one and a half billion feet. Of this, about half is Douglas fir. The results of tests are given to show how this wood has a higher modulus of elasticity than other kinds of pine and pictures to illustrate what large sizes can be procured. One of these shows three car loads of timbers, measuring 18 in. by 18 in. by 70 ft. long.

Tube-Well Strainers.—Messrs. Stewarts and Lloyds, Limited, of 41, Oswald-st., Glasgow, have introduced a new form of strainer for preventing the ingress of foreign matter into tube wells, which has been invented by Mr. John Ashford, superintendent of the Central Workshops, P.W.D. Amritsar, Punjab, India. The strainer takes the form of a very finely wound helix of wedge-shaped wire, wound on a strong framing, which leaves openings of about one-hundredth of an inch for the passage of the water. These are small enough to prevent any but the very finest sand getting into the well, which can thus be pumped from freely, without fear of cavitation. Ingenious devices have been evolved for connecting the lengths of strainer together and for getting it in place in the well.

Primary Batteries.—The Edison & Swan United Electric Light Company, Limited, of Ponders End, Middlesex, have sent us a leaflet describing their "H_2O" cells. This is really a very compact form of Leclanché cell supplied ready for putting into service as soon as it has been filled with water. It has, however, several advantages over its prototype in that it is not liable to "creeping" or evaporation while it is in use, its internal resistance is comparatively low, and it does not polarise so quickly. Besides this these cells can be sent to, and stored in, any climate without deterioration. Another leaflet from the same company advocates the use of buzzers, in the place of electric bells, in certain circumstances, and gives particulars of the "Esco" buzzer.

Steel Structures.—The illustrated catalogue of steel structures manufactured and erected by Messrs. Edward Wood and Co., Limited, of Ocean Iron Works, Manchester, and 81, Cannon-street, London, E.C., contains examples of buildings from all parts of the world, and for a great variety of purposes. There are several pages of roof principals with spans varying from 20 to 100 ft. Details of roof coverings, ventilators, louvres, steel stanchions and flooring occupy seven pages. Then come 75 pages mainly filled with photographic representations of warehouses, show-rooms, office buildings, stables, meat factories and refrigerated stores, engineering workshops, iron and steel warehouses, machine shops, foundries, steel-smelting shops, erecting shops, joiners' shops, gas works, coal stores, power stations, car sheds, theatres, mills and factories for rubber tyres, soap, bookbinding, condensed milk, printing and spinning and dock sheds. Bridges occupy eight pages, and are followed by a number of corrugated steel buildings, including a pagoda building enclosing a large Buddha in Burmah, several exhibition buildings, and a number of grain elevators. There is scarcely a structural purpose to which steel can be applied which is not illustrated in the volume. Many well-known engineering firms appear in the list of clients of the firm.

Coffee Machinery.—A striking catalogue which has just been issued by Messrs. Wm. McKinnon and Co., Limited, of Spring Garden Iron Works, Aberdeen, is claimed to be the first complete publication of its kind. It has evidently been produced regardless of expense, and justifies the assertion that it is not merely a catalogue but is also a book of reference, for there are many hints to planters as to the best methods of operation. The Spring Garden Iron Works were founded as long ago as 1798, and for the last 70 years have made a speciality of coffee machinery; they are thus well acquainted with the requirements of the industry, and have introduced a number of improvements in the design and manufacture of their products. One of these concerns the "breasts" of coffee pulpers. In order to overcome the trouble of adjustable breasts rusting and choking up, the doors are formed by making a fine saw-cut up the main casting. This is carried up so far that the flexibility of the casting permits of the adjustment of the door, and thus does away with troublesome hinge-pins. Another improvement is the employment of rubber strips to form the pulping bar. It is then possible to treat green, ripe and dry coffee cherries simultaneously, just as they are picked. The green and dry cherries pass the rubber strips, unharmed, for other treatment, while the ripe cherries are properly pulped. Mechanical drying apparatus naturally occupies a considerable amount of space in the catalogue, and its advantages over sun drying are emphasised. Among the dryers, one of the most noteworthy is that heated by electricity, which has been evolved to meet the demands of planters in British East Africa. Schemes for complete coffee-curing plants are outlined, and every requisite for their installation catalogued.

The Swedish State Railways.—As might be expected from the vastly increased traffic owing to the war, the receipts of the Swedish State railways for 1916 far exceed those of any previous year, the aggregate amounting to a sum of 150,000,000 kroner, against 118,000,000 kroner for 1915 and 93,000,000 kroner for 1914. Owing to the largely increased working expenses, the net profits do not show any increase, the reverse, in fact, being the case, inasmuch as the net profits for 1915 are not expected to exceed 25,000,000 kroner, against 27,000,000 kroner for 1915. The increase in ton-kilometres compared with 1915 is about 30 per cent., and the aggregate number of ton-kilometres for the goods traffic for the years 1915 and 1916 show an increase of 118 per cent., compared with 1914. Of the increase in receipts for 1916, as compared with the previous year, these are 37 per cent. on the goods traffic and 22 per cent. on the passenger traffic. The increase in express train passenger receipts amounts to 25 per cent.